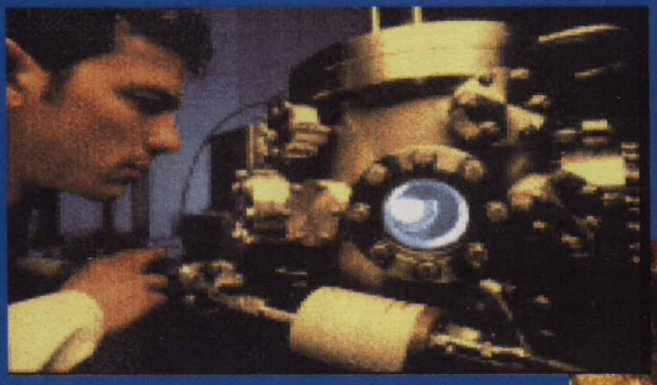
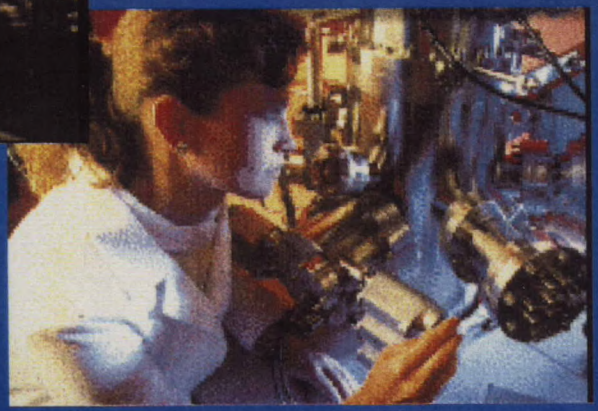
Microelectronics Research Activities in Canada





Branch

Industry Canada

Microelectronics Research Activities in Canada

ICTM Branch

Industry Canada

FOREWORD

This document focuses on some of microelectronics research we have identified in Canada. It is the intent of this guide to include the majority of major non-profit organizations engaged in research and development of microelectronics within Canada. The major loci for this R&D activity was found to be at university centres which are provided financial assistance through Centres of Excellence and government at all levels.

The federal and provincial governments of Canada are actively involved in establishing and funding research initiatives within universities and industry. The three main funding sources for R&D in Canada can be traced to the National Research Council (NRC), the Natural Sciences and Engineering Research Council of Canada (NSERC), and Industry Canada.

The Natural Science and Engineering Research Council of Canada along with Canadian Microelectronics Corporation, Micronet, and Canadian Institute for Telecommunications Research support their research through various university research campuses across Canada. The CRC also supports research in the areas of millimetre wave devices and circuitry. An introduction is given to each of the above mentioned institutes followed by an account of current activities being conducted by their researchers at universities across Canada.

We have made a concerted effort to ensure the accuracy and completeness of this compendium, however, as this is a dynamic and evolving sector, we cannot be held accountable for missing or inaccurate information. The content and timeliness of information contained in this document does not reside solely with Industry Canada since it is the joint responsibility of the semiconductor researchers involved in this sector to help us define the microelectronics and semiconductor research occurring in Canada.

We encourage collaboration between the university research community and Canadian firms. Another objective of this document is to help to promote the exchange of people, ideas and innovative technologies between industry and academia. Our goal is to develop collaboration and promote the sharing of competencies between scientists, academia and industry.

For more information, please contact the author at the following co-ordinates:

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Canada Has a Highly Skilled Workforce

RANKING OF ELECTRICAL ENGINEERING UNIVERSITY PROGRAMS			
Institution	**Score**	**U.S. Rank**	**Cdn. Rank**
M.I.T.	4.93	1	
Stanford	4.92	2	
Berkeley	4.89	3	
Toronto	**4.87**		**1**
Illinois	4.85	4	
McGill	**4.84**		**2**
McMaster	**4.84**		**3**
UCLA	4.83	5	
U.B.C.	**4.82**		**4**
Cornell	4.80	6	
Purdue	4.77	7	
Southern California	4.76	8	
Princeton	4.75	9	
Saskatchewan	**4.75**		**5**
Michigan	4.74	10	
Calgary	**4.74**		**6**
Carnegie Mellon	4.73	11	
Alberta	**4.73**		**7**
Polytechnique	**4.73**		**8**
Queens	**4.73**		**9**
Source: 1993 Gourman Report			

- The U.S. Gourman report scored 9 Canadian electrical engineering programs in the top 20, and 19 in the top 40
- Canada's 67 universities and colleges produce more than 25,000 graduates per year in math, engineering and pure and applied sciences
- Canada has the highest rate of post-secondary enrollment in the world

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Microelectronics Research Infrastructure

Recognized Universities

Microelectronic Research Infrastructure

Alberta Microelectronics Centre

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Edmonton, Alberta
T6G 2T9
Tel.: (403) 492 - 3914
Fax: (403) 492 - 1643
E-mail : info@amc.ab.ca
Web: http://www.amc.ab.ca

Contact: Chris Lumb (President & CEO)

Company Background: The Alberta Microelectronics Centre (AMC) was created a decade ago as a centre of expertise in microelectronic technology that would transfer its knowledge and skills to industry to assist regional economic diversification. Owned by the University of Alberta and funded, in part, by the government of Alberta, the Centre has grown to become one of Canada's leading microelectronic research and development facilities.

In Partnership: AMC has formed many strategic alliances which has allowed AMC to grow in the microelectronics sector. With partnerships with the University of Alberta and the University of Calgary, AMC has access to a wide pool of new graduate students and the top professors in the electronics fields. Partnerships with the Canadian Microelectronics Corporation (CMC), Canadian Advanced Technology Association (CATA), Industrial Research Assistance Program (IRAP), and the Alberta Technology Network (ATN) make AMC a leading-edge research institute in Canada.

Research Capabilities

- Design Engineering
  - Electronic Circuit & PCB Design
  - System Design & Integration
  - ASIC & FPGA Chip Design
  - DSP & Micro-Controller/Processors
  - Sensor Interface Design
- Thin Film Materials & Devices Laboratory
  - Silicon Micromachining
  - Micro Sensors
  - Thin Film Coating
  - Photonics
  - Custom Design
  - Process Development
  - Low Volume Manufacturing
- Consulting
  - Feasibility Studies
  - Project Management
  - Technology Review
  - Manufacturing Analysis

Applied Microelectronics Inc. *

1046 Barrington Street
Halifax, Nova Scotia
B3H 2R1
Tel.: (902) 421 - 1250 xtn: 273
Fax: (902) 429 - 9983
E-mail: taylor@appliedmicro.ns.ca
Web: http://www.appliedmicro.ns.ca

Contact: Darren W. Taylor (Director of Business Development)

Company Background: Founded in 1981, Applied Microelectronics Inc. (AMI) is an established leader in the design and development of electronic based products. AMI's technology and project management expertise help clients bring quality products to market quickly and cost effectively. Since it's opening over 15 years ago, AMI has grown from a small organization to over 40 full time employees.

AMI contributes to client competitiveness through collaborative teaming. By providing a fixed price, defined delivery time and specification guarantees, AMI assists clients in meeting manufacturing cost constraints.

Research Capabilities

- Application Specific Integrated Circuits (ASICs) Design and Development
- Field Programable Gate Arrays (FPGAs)
- Programmable Logic Device (PLD) Design
- Complex Programmable Logic Device (CPLD) Design
- Radio Frequency (RF) Design Capabilities
- Microcontroller Development
- Digital Signal Processing
- High Performance Digital Systems
- CAD / CAE Services
- Broad Level Simulation
- Conceptual Design
- Demonstration Prototypes
- Manufacturing Prototypes

Research Centre: Applied Microelectronics maintains a modern design, prototype and test laboratory in a 12 000 square foot facility located in downtown Halifax, Nova Scotia. Some of the testing and prototype equipment available to the researchers at this facility is logic testing and analysis to 500 MHZ.; Spectrum analysis (250 microHz to 2 GHz); RFI testing; NTSC signal generation and monitoring; TEMPEST rated shield room; Satellite dish, receiver, etc; EPROM, FPGS, PLD programming; and surface mount assembly station.

Product Development: AMI has worked with and in unison with many companies in the past years to create products which are on the market today. In collaboration with Nautel, AMI has created a Digital FM Exciter and a Direct Carrier Control. In 1994, AMI with Hermes Electronics Inc. they created the Sonobuoy UEU. Currently, AMI is working on many projects with companies such as Vemco Ltd., SPAR, SamSys Inc., and COMDEV in the microelectronics sector.

* formerly a non-profit organization, now a commercial firm

Customer Relations: AMI's success can be easily linked to the satisfied customers of AMI's Research and Development teams. It is a proven track record that AMI brings to the table whenever a client approaches them. It is this track record which has allowed for long term relationships and return business that has fuelled the growth of AMI. Electronic firms such as Nautical Electronics Laboratories Ltd., J.J. MacKay Canada Ltd., and Landmark Communications rely on the expertise of Applied Microelectronics Inc. to work together on their research and development.

Canadian Institute for Telecommunications Research (CITR)

McGill University
3480 University, Suite 633
Montreal, Quebec
H3A 2A7
Tel.: (514) 398-7116
Fax: (514) 398-4470

Contact: Dr. Maier Blostein

The Canadian Institute for Telecommunications Research (CITR) is a distributed research institute devoted to enhancing Canada's telecommunications industry through university-based research. It is managed jointly by 21 universities and specialized research centres in collaboration with 18 industrial companies which involves more than 60 professors and 220 postgraduate students.

Research: CITR is a working and broadband network of the future that provides the resources needed for ubiquitous connectivity between people, between machines and between people and machines. It is a telecommunications services environment offering subscribers virtually instant and transparent access to any type of voice, data or multimedia service and service access from anywhere, e.g. from home, work or any moving plane/train/car. CITR is doing research works in the PCS and LMCS sub-sectors.

Research Program

- Broadband Network Resources Management
- Distributed Multimedia Broadband Services
- Optical Backplane Architecture and Technology
- Broadband Wireless (Indoor)
- Broadband Wireless (LMCS)
- Broadband Satellite Communications
- Integrated Multi-Service Wireless Access Network for PCS at 1.9 GHz

Canadian Microelectronic Corporation

210A Carruthers Hall
Queen's University
Kingston, Ontario
K1L 3N6
Tel.: (613) 530-4653
Fax: (613) 548-8104
E-mail: marxh@cmc.ca

Contact: Mr. Tony Marsh, President

The Canadian Microelectronics Corporation (CMC) is a non-for-profit corporation constituted to support Canadian universities in their pursuit of excellence in research and scholarship in all aspects of microelectronics, and to assist industry in accessing and effectively applying microelectronic technology. It delivers a $10-million annual program with technology resources contributed by industry, funding by the National Science and Engineering Council, and a small but growing revenue stream generated by R&D services. Membership includes 35 universities and 18 industrial organizations, each of which has a member representative as the main liaison with CMC.

Technology Services

CMC services, which are primarily directed to researchers (faculty and graduate students) at its member universities, include the following:

- Coordinating access to seven fabrication technologies
- Negotiating special licensing arrangements or directly distributing selected CAD tools, and providing user support
- For selected fabrication technologies, preparing and distributing design kits for the primary CAD tools (Cadence Design Framework II design tools and Synopsys Synthesis tools) supported by CMC. Full libraries and engineering support are available for
    - Nortel 0.8-micron BiCOMS — Cadence, Synopsys
    - Nortel 0.8-micron SAGRF GaAs — Cadence
    - MITEL 1.5-micron CMOS — Cadence, Synopsys
    - Gennum bipolar linear array — Cadence
    - FT14 bipolar linear array — Cadence
    - Hewlett-Packard 0.5-micron CMOS — Cadence
    - Rapid Prototyping Board — Mentor, Synopsys, Xilinx
- Providing training support for the above tools and technologies, including on-line tutorials about design flows. Current instructional materials include:
    - Tutorial on Digital IC Design Flow
    - Design Flow for Scan-based DFT
    - Physical Test of a Digital IC (CMC/SCM Test Head and VXI)
    - System Design and Rapid Prototyping Training Workbook
    - Rapid Prototyping Board Design Flow Overview and User Guide
    - An Introduction to Micromachining: Results of Projects Using Mitel's 1.5-micron CMOS Technology to Develop a Canadian MEMS Process

Faculty and Students

On an annual basis CMC programs are used by more than 400 academic faculty and almost 700 PhD and MSC students in areas related to microelectronics research. In 1995, 118 graduate-level courses in microelectronic subject areas were delivered at Canadian universities.

Communications Research Centre (CRC)

3701 Carling Avenue
P.O. Box 11490, Station "H"
Ottawa, Ontario
K2H 8S2
Tel.: (613) 998-2266
Fax: (613) 990-8369
E-mail: rene.douvill@crc.doc.ca

Contact: René Douville, Director, Antennas and Integrated Electronics

The Communications Research Centre (CRC) is the Government of Canada's major facility dedicated to research in advanced telecommunications and information technologies. Its particular strengths are in wireless systems, including satellite systems. With a staff of over 220 scientists and engineers, it conducts R&D programs in the areas of:

- wireless, mobile and satellite communications
- TV and radio broadcast technologies
- radio propagation and prediction
- antenna technologies
- microelectronics
- optoelectronics and photonics

In 1974, CRC designed the first microwave GaAs MESFET amplifier to fly in space. Other technological achievements include advanced GaAs and silicon digital IC and mulitichip module designs for high-speed signal-processing functions such as FFTs, complex multipliers, and wideband digital receivers; microwave and millimeterwave integrated circuits; miniature hybrid microwave integrated circuits (MHMICs); surface acoustic wave design and fabrication; and multiwavelength optical network components.

Microelectronics-Related Expertise and Services Provided

- High-speed DSP and ASICs and multichip module design
- Microwave and millimeterwave ICs using monolithic and miniature hybrid technologies to 60 GHz in both GaAs and SiGe
- Planar and integrated active microwave and millimeterwave antennas
- Optoelectronic devices and components for integrated circuit (OEIC) applications
- System design for wireless telecommunications and broadcast applications

CRC boasts modern microelectronics fabrication facility with full capability for prototyping and packaging of thin-film miniature hybrid circuitry and GaAs optoelectronics devices. It has a full complement of the latest in microwave circuit design, electromagnetic simulation, and antenna design softwares, and uses a suite of Mentor-based digital IC design tools.

Business Description: CRC carries out contract R&D, generally in support of Canadian industry. It also accepts contracts form offshore in areas of expertise where capabilities complement or do not reproduce existing national industrial capability. It maintains a database of licensable technology, and licences may be negotiated. CRC's facilities and expertise may be accessed through its Technology Incubator program, which is aimed at small and medium-sized companies. Clients have daily contact with our skilled researchers, and have access to centralized research support services, including a technical library, graphics arts and technical design facilities, a modes shop, and a PC board prototyping facility. The CRC has a large number of collaborative agreements with companies, universities, and research organizations in Canada and aborad. It can link its clients with these organizations for potential collaboration or for access to technologies.

Micronet

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Web: http://www.utoronto.ca/micronet

Contact: Mr. Maher Bitar, Manager

Major Achievements

- The Network was instumental in the creation of two SME spin-off companies resulting from the Precompetitive Resarch Program
- In 1995/96, the Network generated 68 M.A.Sc's and 53 Ph.D's, 80% of whom are employed in Canada.
- Direct industrial cash contributions to the Network's Precompetitive Research Program increased from zero in Year I to $100K in Year II and $720K in Year III.

Company Background: Micronet is a collaborative network comprising of 20 universities, 30 companies and 4 provincial/federal oragnizations. In 1995/96, the industrial membership of the Network has increased by 63% with the majority of new members being small or medium scale enerprises who are financially contributing to support the Precompetitive Research Program.

Business Description: Micronet's mission is to mobilize Canada's research talent in the academic, private and public sectors and apply it to strengthen the competitive ability of the Canadian microelectronics and information technology industries. Micronet's objectives are to stimulate leading edge fundamental and applied research in productivity and economic growth, to accelerate the exchange of research results within the Network, to enhance Canada's industrial competietveness in the microelectronics sector, and to manage multidisciplinary, multisectoral research programs of nationwide scope.

National Optics Institute

369 Franquet Street
Sainte-Foy, Québec
G1P 4N8
Tel.: (418) 657 - 7006
Fax: (418) 657 - 7009
Web: http://www.ino.qc.ca

Contact: Charles E. Beaulieu

Company Background: The National Optics Institute (NOI) is a private, non-profit corporation founded in 1985. Over one hundred and twenty people are employed at its facilities in Sainte-Foy, including approximately seventy researchers spezialized in the various branches of photonics.

The Institute works in close partnership with the private sector. Its stated mission is to be an international leader in optics and photonics R & D, promoting economic expansion in the country by providing assistance to companies seeking to be more competitive.

In Partnership: NOI is affiliated with many companies. Such companies include Allied Signal Canada, Bell Canada, Centre d'innovation sur le transport de l'énergie du Québec, Institute for Microstructural Sciences (NRC), Nortel and others. Associate members of NOI are comprised of companies and universities. Some of these institutes are Art Inc, Cifra Médical Inc., The Laser Institute, NORDX/CDT, Université Laval, and others.

Research Capabilities

- Optical Systems and Components
  - Optical Design and Testing
  - Diffractive Optics
- Photonics Materials and Processes
  - Microstructure manufactoring techniques
  - Development of Methods to Apply Thin Film Coating
- Photonics and Guided Optics
  - Design, Fabrication, Characterization, and Development of fibre-optic devices
  - Development of ways of producing integrated optics from doped silica, polymers, and lithium niobate
- Laser System Technology
  - Design of complex laser systems
  - Designing and producing laser sources
- Information Processing
  - Optics-related information processing methods and systems.
  - Digital signal processing

National Research Council of Canada (NRC)

Montreal Road
Ottawa, Ontario
K1A 0R6
Tel.: (623) 993-9369

Contact: Dr. Peter Dawson

The National Research Council is Canada's leading government research and development (R&D) organization. It has 3,000 employees, and 18 research institutes organized into five technology groups: Biotechnologies; Manufacturing Technologies; Construction Technologies; Infrastructural Technologies; and Information and Telecommunications Technologies.

The objective of NRC's Information and Telecommunications Technologies group is to work in partnership with industry on R&D that will enhance the economic impact of information and telecommunications technologies in Canada. There are two research institutes - the Institute for Information Technology and the Institute for Microstructural Sciences with a combined staff of over 200. INMS is responsible for the majority of work being undertaken in solid state physics at NRC.

Core Competencies

- Optoelectronics/photonic integration
- Semiconductor process technology
- Thin film technology
- Acoustics
- Artificial intelligence applications
- 3-dimensional modelling and image acquisition

Semiconductor-Related Programs

- Advanced process development
- Epitaxial growth
- Process control optimization
- Silicon-germanium-based devices
- Optoelectronics WDM transmitter and receiver chips
- Optical thin film technology

Interacting with Universities

- Collaborative projects, often with industry
- Access to NRC facilities for professors and students

Facilities and Capabilities

DEVICE PHYSICS

- Device parameter probe stations for characterizations from 80K to 500K using dc and low-frequency pulse measurements and low-frequency impedance measurements
- High-frequency electrical device testing to 40 GHz
- Small signal laser modulation testing up to 40 GHz
- UNIX workstations for electronic and optoelectronic device design and simulation
- SQUID magnetometer

EPITAXY

The following facilities are available on an occasional basis to government agencies, industry and universities through collaborative or contractual arrangements:

- Production-ready Si-Ge CVD (Chemical Vapour Deposition)
- Two Molecular Beam Epitaxy (MBE) systems for growth of GaAs- and SiGe-based structures
- Chemical Beam Epitaxy (CBE) for growth of InP-based structures
- Single- and double-crystal x-ray diffraction and x-ray reflectometry
- Photoluminescence and photoluminescence-excitation spectroscopy
- Photoresist-free structuring of III-V materials
- Excimer and Nd: YAG laser processing of advanced optoelectronic and microelectronic structures
- Pulsed laser deposition of thin films, quantum wells nd superlattices
- Electrochemical CV profiling

MICROFABRICATION

- Electron beam and thermal vacuum deposition of selected metals
- Rapid thermal annealing
- Reactive ion etching of GaAs, InP, Si and Dielectrics
- UV lithography up to 6"diameter wafers
- Electron beam lithography
- PECVD Oxide, Nitride, Oxynitride and Amorphous Silicon
- Stress measurement of dielectric and metal films
- Thickness and refractive index of dielectrinc films and photoresist
- Ellipsometry of dielectric films
- Device assembly including eutectic die-bonding and wire bonding (Au and Al)
- Oxford Instruments Ionfab300 chemically assisted ion beam etching (CAIBE) system
- Grating photo-mask and holographic printing

OPTOELECTRONICS

- Waveguide and Photonic Integrated Circuit (PIC) evaluation and test facility
- 1.55 μm tunable external cavity diode laser
- Optical spectrum analyser
- Single-shot 500 MHZ and 6 GHz transient digitizers and 40 GHz sampling oscilloscope system
- Long-pulse XeCl laser
- High-power and high-speed laser pulse characterization
- High-power laser diodes
- Sub-picosecond laser sources covering most of the visible and near-infrared regions
- High-power Nd-Yag nonosecond and picosecond sources
- Fast atom bombardment system for simple lithography of semiconductor waveguide materials
- Several solid-state lasers and micro-equipment for integrated circuit work
- Tunable Ti-sapphire, colour centre laser and OPO for PIC and OTDR (Optical Time Domain Reflectometry) work
- Grating and Fabry-Perot spectrometers
- An extensive library of modelling programs
- Room-temperature micro-reflectance and micro-luminescence spectroscopy in the visible and near-infrared; equivalent set-up at 77K in progress
- Near-field microscope

Natural Sciences and Engineering Research Council of Canada (NSERC)

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Web: http://www.nserc.ca

Contact: Mr. Leo Derikx

The Natural Sciences and Engineering Research Council of Canada (NSERC) is the national instrument for making strategic investments in Canada's capability in science and technology. NSERC supports both basic university research through research grants, and project research through partnerships of universities with industry, as well as the advanced training of highly qualified people in both areas.

Budget: In 1966-97, NSERC will invest $450 million in university-based research and training in all the natural sciences and engineering. They support excellent research and training in 60 Canadian universities to over 8,000 researchers.

Excellence Through Peer Review: NSERC uses peer review to adjudicate applications. All funding is awarded competitively, and excellence is always a criterion for funding. Each year, over 500 Canadian experts from the university, industry and government sectors across the country serve on NSERC's policy and expert review committees. These experts volunteer over 13,000 person-days of work annually.

Research Partnerships Program: NSERC Research Partnerships Program funding levers more than 160% of additional funding from industry, universities and government. Over 1,000 Canadian companies have participated in NSERC's Research Partnerships Program to date, and over $300 million has been levered by NSERC funding. Industry has helped Canadian universities to establish more than 200 research positions in the past 12 years using NSERC's Industrial Research Chairs.

Networks of Centres of Excellence (NCEs): NCEs are successful partnerships between universities, industries and governments bringing together researchers in different fields to focus on common problems. In a country with a dilute population and disperse institutions, the NCEs create intellectual critical masses of researchers to work on significant problems, but still leave the scholars in their own institutions to teach students and help industry in their regions. Fourteen networks constitute a proven Canadian concept in focusing researchers on areas of potential economic and social benefit. NSERC supports 10 NCEs, including 2 in partnership with the Social Sciences and Humanities Research Council and 2 in partnership with the Medical Research Council. NSERC chairs both the Steering and Management Committees.

Strategic Investment for Canadians NSERC is a key partner in the nation's research and training effort. Its funding:

- leads to important scientific and engineering advances;
- creates new knowledge to enhance the well-being of Canadians;
- trains highly qualified people;
- transfers new technologies to industry;
- encourages industry to invest in university research;
- provides access to international technologies, knowledge and expertise;
- leads to process and product innovation;
- creates new companies and industries;
- creates jobs

*Telecommunications Research Institute of Ontario * (ITRC)*

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Contact: Peter Leach (President)

Mission Statement: TRIO's mission is to enhance the technological competitiveness of Canadian telecommunications companies through university/industry partnerships in focused and shared research led by the best Ontario researchers, and to:

- create world class technology relevant and transferable to Canadian industry
- increase the flow of trained researchers into relevant areas of technology
- expand and enhance the educational infrastructure to achieve a permanent increase in quality and capability of TRIO member universities

Collaborative Ventures: TRIO has been involved in many collaborative ventures in the past year with corporations such as Newbridge Networks, Mitel, Nortel, Aprel, Philsar, and many more. TRIO and ITRC jointly examined a number of initiatives which addressed strategic business opportunities for both industrial sectors and the emerging digital content sector. One joint venture includes a research framework proposal which is under discussion with Microcell 1-2-1, Clearnet, and Mobility Canada. This is just one of many ventures which puts TRIO on the cutting edge of technology.

TRIO has and is expanding corporate relations to provide companies of today the technology to keep them as leading firms in the telecommunications sector. Companies such as Mitel, Nortel, Newbridge, Mosaid, Spectrum Sciences Institute, SGS - Thomson and others benefit from the expertise that TRIO brings to the research and development processes. TRIO has been funded by the Ontario government and its activities were merged with ITRC in 1997.

Research Topics:

Very High Speed Circuit Design and Test

- MMIC Design and Test
- EM Modelling of VHS Radiation Testing
- High-Speed Active Integrated Circuits

Antennas and Signal Processing

- Integrated Antenna Systems
- Signal Processing for Telephony
- Advanced Signal Processing for Communications
- Antennas for Feed Circuits for Personal Communications and Spacecraft Applications

Photonics Networks and Systems

- Optical Network Access Technology
- Fibre Networks Systems
- Optoelectronic Devices

* integrated with ITRC in 1997

Mobile and Satellite Systems

- Mobile and Portable Networks
- Digital Communications
- Mobile and Satellite Systems
- VLSI in Communications
- Secure Wireless Communications

Protocols and Software Engineering

- Telecom Software Methods
- Phototyping and Validation Tools

Enterprise Networks

- Interconnected Networks for Multimedia Traffic
- Broadband Packet Switching Networks
- Fault Management of Networks

TRLabs

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10611 - 98 Avenue
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T5K 2P7
Tel.: (403) 430-7543
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Contact: Michael Leung (Vice President , Business Development)

Background: TRLabs is an applied research consortium based on industry, university and government collaboration. Founded in 1986, this western based group has grown to include 36 partners. They have grown to include research laboratories in Edmonton, Calgary, Saskatoon, Regina and Winnipeg. TRLabs is researching into five strategic technologies which are: Networks and Systems Research; Photonics; Wireless; Network Access; and Data Networking and Related Software.

Research Topics

- circuit-switched multicast video conferencing networks
- DS-1/DS-3 error correcting VLSI
- integrated components for WDM systems
- channel characterization
- interference cancellation in spread spectrum systems

Research Papers

A.C.K. Soong, W.A. Krzymien, "Performance of a Reference Symbol Assisted Multistage Successive Interference Cancelling Receiver in a Multi-Cell CDMA Wireless Systems," GLOBECOM '95 Conference Record Communication Theory Mini-Conference, Vol. 1, pp. 152-156, Singapore, November 1995.

A.B. Sesay, M.R. Gibbard, "Asymmetric Signal Processing for Indoor Wireless LANs," Proceedings of the Sixth International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC '95), Vol. 1, pp. 6-8, Toronto, ON, September 1995.

R.Nagarajan, J.N. McMullin, "Fabrication and Testing of Silicon V-Groove Gratings," Technical Digest Optical Society of America Annual Meeting, Poster Paper, September 10-15, 1995.

K.R. Prasad, Q.Z. Liu, R.I. MacDonald, "Analysis of a Fibre Microwave Link with Optoelectronic Up-converter for Wireless Applications," Proceedings of the Wireless Communications Conference, part of SPIE's 1995 International Symposium on Optical Science, Engineering and Instrumentation, San Diego, CA, July 1995.

A.C.K. Soong, W.A. Krzymien, "CDMA Multi-User Interference Cancellation with Reference Symbol Aided Estimation of Channel Parameters," Proceedings of the IEEE Pacific Rim Conference, pp. 429-432, Victoria, BC, May 1995.

J.P. Peters, B. Rahardjo, "Higher Order Logic in Reasoning About Asynchronous Circuits," Proceedings of IEEE Wescanex '95, Communications, Power, and Computing, Vol. 1, pp. 74-78, Winnipeg, MB, May 15-16, 1995.

T. Seniuk, Q.Z. Liu, G.D. Cormack, "1x8 Metal-Semiconductor-Metal(MSM) Photodetector and HEMT Receiver Array with 5 GHz Bandwidth," Proceedings of 1995 IEEE MTT-S International Microwave Symposium, pp. 53-56, Orlando, Florida, May 15-19, 1995.

L. Tomba, W.A. Krzymien, "On the effect of chip synchronization error in MC-CDMA systems," 1996 Workshop on Multiaccess, Mobility and Teletraffic for Personal Communications (MMT '96), Paris, France, May 20-22, 1996, and published in Multiaccess, Mobility and Teletraffic for Personal Communications, B. Jabbari, P. Godlewski, X. Lagrange (Editors), Kluwer Academic Publishers, Boston 1996, pp. 43-56.

University Supported Research

Carleton University

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Fax: (613) 520 - 5708

Contact: Dr. J.S. Wright (Professor and Chair), Dr. Tad Kwasniewski (Professor)

Background: Carleton University serves as a research centre functioning on the government support and corporate backing of research projects. Microelectronics firms such as Micronet and Nortel Semiconductor support many projects currently being studied by some of Carleton's best Electronic's professors.

With regard to integrated circuits, the current research being supported at Carleton is high-speed analog/digital conversion, adaptive analog filtering at radio frequencies, and high-speed digital-signal processing. In the area of Computer-Aided Design (CAD) current research is focused on analysis and optimization of high-speed circuits and their interconnects, multidisciplinary optimization, statistical simulation and design methodology, noise analysis, and CAD for fibre optic communication. Carleton's Electronic Department is well known for its bipolar and BiCMOS RF radio chipset designs.

Research Topics

"Basic Design, Modelling, and Applications of Semiconductor Devices"
(A.R. Boothroyd, NSERC)

"Integrated Circuit Design and Application"
(M.A. Copeland, NSERC.)

"Monolithic VCO's in BiCMOS" , "SAW Interfacing for BiCMOS RF"
(M.A. Copeland, Northern Telecom Electronics Ltd.)

"Circuit Techniques and Design Methodology for CMOS and BiCMOS Frequency Synthesis Components for Gigahertz, Low-Power Communications Applications"
(T.A. Kwasniewski, NSERC)

"Mathematical Optimization of BiCMOS VLSI Systems"
(M.C. Lefebvre, Micronet)

Recent Publications

"A Chip Set for Pipeline and Parallel Pipeline FFT Architectures"
C.H. Chan (with V. Szwarc, L. Desormeaux, W. Wong, C.P.S. Yeung, and T.A. Kwasniewski)

"A Low-Voltage Silicon Bipolar RF Front-End for PCN Reciever Applications"
M.A. Copeland (with J. Long, P. Schvan, and R.A. Hadaway)

"Monolithic Microstrip Inductors and Transformers in Silicon BiCMOS"
M.A. Copeland (with J.R. Long)

"CMOS High-Speed Dual-Modulus Frequency Divider for RF Frequency Synthesis"
T.A. Kwasniewski (with N. Foroudi)

"Signal Integrity Analysis and Optimization of VLSI Interconnects Using Neural Network Models"
M.S. Nakhla (with Q.J. Zhang)

"Simulation and Analysis of Electromigration Failure Distributions"
T.J. Smy (with S.S. Winterton, S.K. Dew, and M.J. Brett)

"Composition Grading for Base Transit Time Minimization in SiGe Base Hetero-junction Bipolar Transistors"
N.G. Tarr (with S.S. Winterton, C.J. Peters)

"Concurrent Thermal and Electrical Optimization of High-Speed Packages and Systems"
Q.J. Zhang (with K.Mihan, B. Stacey, M.S. Nakhla)

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Contact: J.C. Giguere, Chair

Background: Concordia University (formerly Sir George Williams) was founded in 1974 by the merging of two of the oldest institutions in the area, Concordia offers a history of excellence for it's students and researchers.
Microelectronics research at Concordia embraces many important areas from how communication links interact in a network to the study of integrated circuits and VLSI design.

Research Topics

Area-efficient fault tolerant systolic arrays

CAD tools for high level synthesis, architecture synthesis, design methodology and architecture style design for high performance signal processing applications. The applications include single and multi-channel filters, multi-rate filters, image compression, neural networks and encoders/decoders.

CAD tools for partitioning signal processing systems and automated placement on multiple FPGA's.

Combinatorial Optimization for VLSI Design and Testing

Design of BIBO stable time-varying discrete all-pass filters with functional singularities (Ideal Null Filters) providing a practical solution for synthesis of structural multiplexers capable of simultaneous transmission of both speech and data.

Design of neural network algorithms for signal processing; Hebbian learning algorithm for adaptive filtering.

Design of weighted order statistic filters using stack filter architectures.

Design of special DSP Building Blocks, based on the use of Almost-Symmetrical Time-Varying ARMA modelling, for the separation of broadband signals (particularly speech signals) with overlapping Fourier spectra. Application - Active Acoustic Noise Cancellation.

Design of new DFT algorithms and their structures.

Design of novel nonlinear structures, providing a practical solution to the problem of rejecting signals whose parameters are a priori unknown (Parameter Invariant Filters)

Development of current-mode circuits for the design of A/D and D/A converters.

Development of analytical approach for the design of 2-D zero-phase FIR filters.

Graphs and Algorithms in VLSI Design
Microelectromechanical Systems, (Microsensors, Microactuators, 2-D micromachine accelerometer).

Neural network based control algorithms and implementation techniques for applications in robotics and power systems.

Parallel Algorithms for VLSI CAD

Performance optimization and system clock determination for synthesis of DSP cores targeting FPGA's

Power conscious high level synthesis of DSP Algorithms

SiO_2 Films for Thin Gates Dielectrics (Corona-discharge oxidation for ULSI, Electrical characterization of fluorinated and nitride oxides).

System Level Diagnosis and Fault-Tolerant Systems

VLSI implementation issues of high performance DSP systems including clock distribution, low power dissipation design and interfacing to analog (A/D & D/A).

Recent Publications

C.R. Zou, E.I. Plotkin, M.N.S. Swamy, "2-D Fast Kalman Algorithms for Adaptive Parameter Estimation of Nonhomogeneous Gaussian-Markov Random Field Model", IEEE Translations on Circuits and Systems - II: Analog and Digital Signal Processing, Vol. 41, No. 10, 1994.

E.I. Plotkin, M.N.S. Swamy, Y. Yoganandam, "A Novel Iterative Method for the Reconstruction of Signals from Nonuniformly Spaced Samples", Signal Processing, Vol. 37, 1994.

R. Agarwal, E.I. Plotkin, M.N.S. Swamy, "Design of a Notch Filter with Improved Performance", International Journal of Circuit Theory and Applications, Vol. 22, 1994.

P.Y. Zhao, E.I. Plotkin, M.N.S. Swamy, "Exponentially Fading MLS Estimation of 2-D Noncasual and Nonstationary SAR Model Parameters", Signal Processing, Vol. 37, 1994.

S.V.Narasimhan, G.R.Reddy, E.I.Plotkin, "Group Delay Based Magnitude Square Coherence Estimation by an ARMA Model", M.N.S. Swamy, Signal Processing, 1995.

R. Agarwal, E.I. Plotkin, M.N.S. Swamy, "LMS-Optimal Notch Filters with Improved Frequency Response", Intern. Journal of Circuit Theory and Applications, 1995.

William E. Lynch, Amy R. Reibman, Bede Liu, "Post Processing Transform Coded Images Using Edges", submitted to IEEE Transactions on Image Processing.

C.R. Zou, E.I. Plotkin, M.N.S. Swamy, "Recursive-in-Order Lest-Square Parameter Estimation Algorithm for 2-D Non-causal Gaussian Markov Random Field Model", Circuits, Systems, and Signal Processing, Vol. 14, No.1, 1995.

William E. Lynch, Amy R. Reibman, "Transform Coding with Edge Compensation" , Bede Liu submitted to IEEE Transactions on Image Processing.

Venkat Ramachandran (coauthored with P.V. AnandaMohan and M.N.S. Swamy), "Switched Capacitor Filters: Theory, Analysis and Design", Prentice-Hall Inc., 1995.

E.I. Plotkin, "Signal-Controlled Time-Series Modelling Based on ARMA Blocks, and Separation of Superimposed Overlapping Spectra Signals" IEICE Trans. on Fundamentals, Special Section on Nonlinear Theory and Applications, Vol. E79, No. 10, 1996

W. Tong, E.I. Plotkin, M.N.S. Swamy, "Active Acoustic Noise Cancellation with Audio Signal Enhancement Based on Almost-Symmetrical Time-Varying ARMA Model", The Journal of A), Vol. 99, No. 6, 1996

J. Romero, E.I. Plokin, M.N.S. Swamy, "Reproducing Kernels and Use of Root Loci of Special Functions in the Recovery of Signals from Nonuniform Samples.", Signal Processing, Vol 49, 1996.

W.P. Shu, M.O. Ahmad, M.N.S. Swamy, "An Analytical Approach for Obtaining a Closed-Form Solution to the Least-Square Design Problem of 20D Zero-Phase FIR Filters", IEEE Trans. on Circuits and Systems, Part II, Vol. 41, No. 11, 1994

K. Gao, M.O. Ahmad, M.N.S. Swamy, "A constrained Anti-Habian Learning Algorithm for Least-Squares Estimation with Applications to Adaptive FIR and IIR Filtering", IEEE Trans. on Circuits and Systems, Part II, Vo. 41, No. 11, 1994.

D. Sundararajan, M.O. Ahmad, M.N.S. Swamy, "A Fast FFT Bitreversal Algorithm", Trans. on Circuits and Systems, Vol. 41, No. 10, 1994

Q. Gu, M.N.S. Swamy, "On the Design of a Board Class of 2-D recursive Digital Filters", IEEE Trans. on Circuits and Systems, Part II, Vol. 39, No. 9, 1994.

H.A. Ahmed, A.J. Al-Knalili, L.M. Landsberger, M. Kahrizi, "A 2-D Micromachine Accelerometer", IEEE Trans. on Instrumentation and Measurement, (submitted 1995)

M. Esonu, A.J. Al-Khalili, S. Hariri, D. Al-khalili, "Design Techniques for Fault Tolerant Systolic Array Architecture", Journal of VLSI Signal Processing, Vol. 11, No. ½, 1995

École Polytechnique

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Contact: John Currie (Professor)

Background: École Polytechnique is the leading university in Quebec for microelectronics research. The microelectronic research being carried out here is supported by all levels of government and industry. Research teams are studying a wide variety of topics ranging from heterojunction electrical devices to digital high-performance microchip design. The Thin Film Institute resides at École Polytechnique and industry feels that École Polytechnique is a valuable partner in the microelectronic field for the research that they are currently investigating. Quebec firms like Mitel and Design Workshop collaborate closely with this university's microelectronics research personnel.

Research Topics

Analog and mixed signal VLSI design
Analog and digital high-performance microchip design for applications in telecommunications and parallel processing
Built-in self-test of digital circuits and systems
Defect and fault-tolerant architecture
Design methods of high speed clocking network
Device design, fabrication and testing
Fibre optic systems and local area networks
GaAs, BICMOS and CMOS high performance circuit structures
Gigahertz modulation
Heterojunction electrical devices
High speed optical interconnects for on-chip access
High-level synthesis & system-level synthesis
High speed data acquisition systems
High-speed (GHz) mixed-signal design
Optical interconnects
Optical circuits and optical switches
Optoelectronic phonic devices for OEICs;
Parallel architectures for integration
Self- testing design methods
Semiconductor materials for photonic emitters and detectors, mostly GaAs and InP
Solid State micro-sensors and MEMS actuators
Testability of analog and mixed integrated circuits and systems
ULSI architecture and design methods
Very high level synthesis, hardware software co-design
WSI design methods

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Contact: Mohamed Chaker (Professor)

Background: Institut National de la Recherche Scientifique (INRS) is a recognized leading research facility in the Quebec area for microelectronic research. INRS is currently on the cutting edge of microelectronics research organizations such as Micronet which are currently involved in x-ray lithography and plasma processing at this institution. Currently there are about 20 staff working on projects comprising graduate students, professors and technicians.

Research Topics

X-ray lithography:

- studies of laser created X-ray sources
- development of a powerful 3D simulation code for x-ray lithography
- implementation of advanced processes for x-ray mask fabrication
- device fabrication using a complete X-ray lithography process.
- X-ray mask fabrication based on SiC and W materials

Plasma processing: The specific materials, eg. SiC, W, diamond-like C and PZT investigated are of considerable current interest for microelectronics applications. This work includes:

- study of a new ECR-type plasma source for sub-quarter pattern transfer
- investigation of the laser ablation technique for material deposition
- material characterization studies.

Optimization of deposition processes, eg. PECVD sputtering, laser ablation and etching processes, eg. ECR, Helicon for various materials such as: SiC, PZT, SiGe, W, Pt, Cr and DLC multilayers.

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Contact: Gordan W. Roberts (Associate Professor)

Background: McGill University is an English language institute established in 1821 in Montreal, Quebec. McGill is the oldest of the 4 main universities located in Montreal. For many decades, McGill has been a leader among Canadian universities in graduate studies and research. McGill participates in 13 of the 14 Canadian Networks of Centres of Excellence, three of which are based here. It is this background that allows McGill to achieve their standards of excellence within their research programs. CITR resides at McGill University and in collaboration with the University of Victoria it is doing important research work in wireless communication devices.

Research Topics

Architecture design, aggressive compilation techniques, and the design of a programming model for general-purpose DSP computations.

Dataflow and multi-threaded architectures, their efficient implementation, and their performance evaluation. International collaboration (with GMD, Germany) on the design of super-actor multithreaded architecture is currently underway.

Design automation and automated synthesis

Design, testing and diagnosis of fault tolerant systems

Designed a programming model for steam data structures which is tailored for expressing DSP computations. A method to obtain rate-optimal static scheduling of programs in the above programming model has also been developed.

Developed a new framework for register allocation and for simultaneous register allocation and instruction scheduling. The McGill Compiler-Architecture Tested, McCAT, has attracted several industrial researchers including those from BNR and CRIM.

High performance architecture and systems design methodology

High Performance Analog Circuits for mixed-signal applications (eg. filters A/D and D/A circuits)

Parallel architectures, parallel algorithms, interconnection networks, switching theory

Solid state electronic materials and devices

Test strategies for mixed-signal Ics.

VLSI testing analog circuits design, analysis and simulation

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Contact: John Bandler (Professor)

Background: McMaster University can be traced back to the 1830's, however was not recognized as an university until 1887 where it was incorporated under an act of the Legislative Assembly of Ontario. This institute was named after Senator William McMaster (1811 - 1887) who bequeathed substantial funds to this university. It is the goal of McMaster to educate their students to become the leaders of tomorrow. This attitude is also prevalent in their research studies. It is the combination of government and private industry grants that give McMaster it's funding base for the cutting edge research being done.

Research Topics

Advanced techniques for CAE of large circuits: (1) (monolithic) microwave integrated circuits, MMICs, (2) high-speed VLSI circuits.

Analog fault diagnosis, fault modelling, design for testability.

Design methodology, optional assignment of tolerances and statistical distributions, tuning and yield-driven optimization.

Hierarchical device/circuits/systems modelling at various response levels.

Large-scale optimization, effective one-sided and generalized lp functions and algorithms, and global optimization exploiting both parallel and massively parallel computational systems.

Linear and nonlinear simulation techniques, harmonic balance analysis; sensitivity analysis for fast gradient based design optimization.

Linear/nonlinear device modelling and parameter extraction (MESFETs, HEMTs, HBTs, Schottky diodes, passive components), including statistical modelling.

Nonlinear device modelling and extraction of physical/process/geometrical or equivalent circuit parameters, exploiting multicircuit DC, RF and large-signal device measurements (MESFETs, HEMTs, HBTs, Schottky diodes, passive components), including thermal effects.

Numerical methods for design of integrated circuits and systems.

Response surface modelling; hierarchical device/circuit/system modelling at various response levels. Simulation and optimization in a functionally integrated DC, small-signal, large-signal, multilevel, multicircuit, multidomain, hybrid circuit-theoretic/electromagnetic-field theoretic design environment, suitable for linear and nonlinear circuits operating at high frequencies.

Statistical design methodology and yield optimization.

Statistical modelling: device data bases and key variables.

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Contact: Ezzl El-Masry (Professor)

Background: Technical University of Nova Scotia (TUNS) research into Microelectronics is supported by Micronet and the federal government. Each of these organizations are supporting research into the areas of Circuits and Systems. This includes Analog Signal Processing, examining both Current-Mode Techniques and High Speed processing. Currently there is a team of 10 working closely to delve into the topics mentioned above.

Research Topics

Developments of high performance CMOS current op amps and general building blocks for current-mode (CM) filtering applications. Also, techniques to reduce signal-dependent current feed-through will be developed.

Realizations of programmable CM FIR linear phase filters and analog adaptive filters based on the pulse width modulation (PWM) technique.

Development of CM oversampled delta-sigma modulator with a new CM sampled-data circuit. Efforts will be devoted to high precision and high frequency applications.

Implementation of an artificial neural network with the CM pulse coded (PWM)technique.

Efforts are devoted to very large scale systems (efficient communication between neurons, the modularity and reconfigurality) and learning capability.

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Contact: El Mostapha Aboulhamid (professor)

Background: The Université de Montréal is one of the oldest universities in Canada, founded in 1878. This offers its students a rich heritage of university excellence and prestige. Research is an integral part of the university and some of the best electronics professors in Canada work here. With a staff of over 30 comprised of post-doctoral/research associates and graduate students in microelectronics research alone the Université of Montréal strives to attain a higher level of microelectronic knowledge for its graduates.

Research Topics

Formal verification for digital systems.

Hardware/software co-simulation and co-design

High Level Specifications using multiple paradigms

High Level Synthesis

Performance evaluation of hardware systems

Specification and verification of digital systems behaviour (timing and function) using hierarchical annotated action diagrams (HAAD). Verification by simulation (complete model) or formal (timing only).

Synthesis from HAAD specifications to hardware / software; microcode synthesis for algorithms to execute on a retargetable datapath architecture.

Timing verification of interface specifications and gate-level implementations.
Functional specification of synchronous systems at different time resolution (e.g., algorithm and RTL) using a subset of predicate calculus and Extended Finite State Machines; formal verification based on reachability analysis of explicitly synchronized (through predicates) product machines.

Recent Publications

<u>Book Sections</u>

E. Cerny, F. Corella, M.Langevin, X. Song, S. Tahar, "Formal Verification using Multiway Decision Graphs" in Formal Verification Methods, T. Kropf (eds), Springer-Verlag Publ. 1996

M. Langevin, E. Cerny, J. Wilberg, H.-T. Viehaus, "Local Microcode Generation in System Design" in Code Generation for Embedded Processors, P. Merwedel, G. Gossens (eds.), Kluwer Academic Publ., 1995

E. Lodi, F. Luccio, L. Pagli, X. Song, "Modelli Non Convenzionali per il routing di collegamenti" in Processori Dedicati, L. Lopriore (eds), Milano, Italy, 1995, 93-98

Journal and Conference Proceedings

E.M. Aboulhamid, M. Meknassi, "Multi Partitioning of Networks Using Alternating Objectives", Submitted to IEEE Transactions on CAD, 1995.

I.E. Bennour, E.M. Aboulhamid, "Lower-Bounds on the Iteration and Initiation Interval of Functional Pipelining and Loop Folding", Submitted to Design Automation for Embedded Systems, 1995.

I.E. Bennour, E.M. Aboulhamid, "Les problèmes d'ordonnancement cycliques dans la synthèse des systèmes numériques", Submitted to RAIRO Technique et Science Informatique, 1995

G. Bois, E. Cerny, "Efficient Generation of Diagonal Constraints for 2D Mask Compaction", to appear in IEEE Transactions on Computer-Aided Design, 1996

J. Cloutier, E. Cerny, F. Guertin, "Model Partitioning and the Performance of Distributed Timewarp Simulation of Logic Circuits", to appear in Journal on Simulation Practice and Theory, 1996

F. Corella, Z. Zhou, X. Song, M. Langevin, E. Cerny, "Multiway Decision Graphs for Automated Hardware Verification", To appear in International Journal on Formal Methods in System Design, 1996

F. Guertin, J. Cloutier, E. Cerny, "Effects of Model Partioning on the Performance of Distributed Timewarp Simulation of Logic Circuits", To appear in Simulation Practice and Theory, 1996

K. Khordoc, E. Cerny, "Semantics and Verification of Timing Diagrams with Linear Timing Constraints", Submitted to ACM Transactions on Design Automation of Electronic Systems

S. Nicoloso, M. Sarrafzadeh, X. Song, "On the Sum Coloring Problem on Interval Graphs". Submitted on Algorithmica, 1995.

X. Song, X. Tan, "Channel Routing on a Hexagonal Grid". Journal of Computing and Infromation. 1.1, 1995, 263 - 279

X. Tan, X. Song, "Dexagonal Three-Layer Channel Routing", Information Processing Letters, 55 , 4, 1995, 223 - 228

X. Tan, X. Song, "Routing Multiterminal Nets on a Hexagonal Grid", Submitted to Discrete Applied Mathematics, 1996

A. Abderrahman, E. Cerny, B. Kaminska, "Effective Test Generation for Analog Circuits", International Workshop on Mixed Signal Testing, Grenoble, France. June 1995

K.D. Anon, N. Boulerice, E. Cerny, F. Corella, M. Langevin, X. Song, S. Tahar, Y. Xu, Z. Zhou, "MDG Tools for the Verification of RTL Designs", International Conference on Computer-Aided Verification, 1996 433 - 436

I.E. Bennour, E.M. Aboulhamid, "A Register Allocation Problem Solved by Constraint Logic Programming and Interval Arithmetic", Submitted to International Logic Programming Symposium , Portland, Oregon, 1995.

I.E. Bennour, E.M. Aboulhamid, "Register Allocation Using Circular FIFO's". Submitted to IEEE International Symposium on Circuits and Systems, Genoble, France, 1996.
I.E. Bennour, E.M. Aboulhamid, "Lower Bounds on the Iteration and Initiation Interval of Functional Pipelining and Loop Winding", IEEE Canadian Conference on Electrical and Computer Engineering. Montréal, 1995, 632 - 635.

B. Berkane, S. Gandrabur, E. Cerny. "Les chronogrammes: Sémantique et passage vers un modèle intermédiaire", IEEE Canadian Conference on Electrical and Computer Engineering, Montréal, 1995

B. Berkane, S. Gandrabur, E. Cerny, "Timing Diagrams: Semantics and Timing Analysis", Asian Pacific Conference on Computer Hardware Description Languages, Bangalore, India, January 1996

J. Cloutier, E. Cerny, F. Guertin, "Model Partitioning and the Perfromance of Distributed Timewarp Simulation of Logic Circuits". To appear in Journal on Simulation Practice and Theory.

F. Corella, M. Langevin, E. Cerny, Z. Zhou, X. Song, "State Enumeration with Abstract Descriptions of State Machines", IFIP WGI0.5 Advanced Research Working Conference on Correct Hardware Design and Verification Methods, Frankfurt, Germany, October 1995.

S. Tahar, Z. Zhou, X. Song, E. Cerny, M. Langevin. "Formal Verification of an ATM Switch Fabric Using Multiway Decision Graphs", IEEE Great Lakes Symposium on VLSI, Ames, Iowa, 1995, 106 - 111

Z. Zhou, X. Song, F. Corella, E. Cerny, M. Langevin. "Partitioning Transition Relations Efficiently and Automatically", IEEE Great Lakes Symposium on VLSI, Buffalo, New York, 1995, 106 - 111

Z. Zhou, X. Song, F. Corella, E. Cerny, M. Langevin. "Description and Verification of RTL Designs using Multiway Decision Graphs", IFIP Conference on Hardware Description Languages and their Applications. Tokyo, Japan, September 1995, 575 - 580

Z. Zhou, X. Song, F. Corella, E. Cerny, M. Langevin, S. Tahar, "MDG Tools for the Verifications of RTL Designs", Conference on Computer-Aided Verifcations, New Brunswick, NJ, August 1996.

Z. Zhou, X. Song, F. Corella, E. Cerny, M. Langevin, S. Tahar, "Formal Verification of the Island Tunnel Controller using Multiway Decision Graphs", To appear in Formal Methods in Computer-Aided Design, Pal Alto, California, November 1996.

University of Alberta

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Contact: Dr. Clarence Capjack

Background: The University of Alberta is one of Canada's largest, full service, research intensive universities. The goal of the University of Alberta is to emerge at the turn of the century as a nationally and internationally recognized institute of higher learning. International and industry relevant research is performed here in the microelectronics sector where research is aided by the use of Alberta Microelectronics Centres facilities, MEM's work at the university is recognized world-wide. Researchers have high quality labs and computer resources to further the advancement of microelectronics in Western Canada.

Research Topics

Development and characterization of advanced IC metallization processes.

Microstructure-level simulation of a variety of thin film processes (PVD, CVD, etching) over topography providing film coverage, density, and composition information.

Realistic sputter and vapour transport simulation to predict blanket thickness uniformity, deposition rate, angular distributions, effects of collimation, etc.

Simulation of deposition and patterning processes, including sputtering, chemical vapour deposition and (WD), evaporation, reactive ion etching, and plasma etching.

Study and development of interconnect processes for ULSI.

The simulator, called SIMBAD, is uniquely capable of predicting non-homogeneous properties of films (such as density and composition) deposited over topographical features.

Recent Publications

L.J. Friedrich, D.S. Gardner, S.K. Dew, M.J. Brett, and T. Smy, "Microstructural effects on copper reflow process", 1996 International VLSI Multilevel Interconnection Conf. Proceedings, pp.213 - 218

R.N. Tait, W. Tsai, D.Hodul, D. Su, S.K. Dew, M.J. Brett and T. Smy, "Compositional variation of sputtered Ti-W thin films on topography: TEM/EDX measurements and SIMBAD Simulations." Advanced Metallization and Interconnect Systems for ULSI Applications in 1995, R.C. Ellwanger and S.-Q. Wang Eds., MRS, Pittsburgh, 1996, pp. 311 - 316

T. Smy, K. Sheergar, S.K. Dew, and M.J. Brett. "Simulations and experimental analysis of step coverage and microstructure in vias and contacts at wafer edges.", 1995 International VLSI Multilevel Interconnection Conf. Proceedings, pp. 670 - 672.

University of British Columbia

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Contact: Dr. Mike Jackson

Background: The University of British Columbia is actively involved in the microelectronics field . The advanced microelectronic research is being conducted here by well trained professors and graduate students. Their research in microelectronics include many areas including ultra-high-speed microelectronics, communications, VLSI, and SiGe HBT ultrafast probing systems.

Research work at the University of British Columbia involves industrial collaboration, where students have the opportunity to interact closely with industry, as well as spend time in industrial laboratories.

Research Topics

High Performance Computing and Networks
Power Systems Group and Power Systems Simulation Lab
Radar Remote Sensing Group
Ultrafast probing for SiGe HBTs and Fibre Optics Lab
VLSI Lab

Recent Publications

"Reduced Invasiveness of Non-Contact Electro-Optic Probes in Millimetre-Wave Optoelectronic Characterization,"
A. Zeng, S. A. Shah and M. K. Jackson, IEEE Transactions on Microwave Theory and Techniques, in press.

"Low-Chirp Linearized Optical Modulators,"
M.K. Jackson, patent pending.

"Guided Substrate Waves in Photoconductive Excitation"
S.A. Shah, A. Zeng, M.K. Jackson, L. Pouliot, A. Lecours and J.F. Currie, IEEE Microwave and Guided Wave Letters, to appear in Vol.6, No.9, (accepted May 28, 1996).

"Electro-Optic Characterization of Modulation-Doped Field-Effect Transistors with Monolithically- Integrated Test Fixtures"
A. Zeng, M.K. Jackson, M. Van Hove and W. De Raedt, Optical and Quantum Electronics, accepted in final form February 1996.

"Separating Temporally-Overlapped Waveforms with Electro-Optic Sampling"
S.A. Shah, A. Zeng, W.S. Wong, M.K. Jackson, L. Pouliot, A. Lecours and J.F. Currie, Optical and Quantum Electronics, accepted in final form February 1996.

"Millimetre-Wave Time-Resolved Measurement Near a Discontinuity: Separating Temporally Overlapping Incident and Reflected Signals,"
S. A. Shah, W. S. Wong, M. K. Jackson, L. Pouliot, A. Lecours and J. F. Currie, IEEE Microwave and Guided Wave Letters 6, 79(1996).

"Chirp in Optically-Linearized Mach-Zehnder Modulators and its Effect on Analog Transmission,"
M. K. Jackson, V. Smith, W. Hallam and J. Maycock, in Optical Fibre Communication Conference, Vol. 2, 1996 OSA Tech. Digest Series (Optical Soc. of America, Washington, DC), p.279.

"On-Wafer Characterization of In0.52Al0.48As/In0.53Ga0.47As Modulation-Doped Field-Effect Transistor with 4.2ps Switching Time and 3.2ps Delay,"
A. Zeng, M.K. Jackson, M. Van Hove and W. De Raedt, Applied Physics Letters 67, 262 (1995).

"InP-Based HEMT Technology for MMIC Applications"
M.Van Hove, J. Finders, K. vander Zanden, W. De Raedt, M. Van Rossum, Y. Balyens, D. Schreurs, B. Nauwelaers, A. Zeng and M.K. Jackson, invited paper presented at State-of-the-Art Program on Compound Semiconductors (SOTAPOCS XXIII), 188th Electrochemical Society Meeting, Chicago, October 8-13, 1995.

"Monolithically-Integrated Coplanar Stripline and InAlAs/InGaAs Modulation-Doped Field-Effect Transistors with 4.2ps Switching Time and 3.2ps Delay"
A. Zeng, M.K. Jackson, M. Van Hove and W. De Raedt, in Conference on Lasers and Electro-Optics, (May 21-26, 1995, Baltimore, Maryland), vol 15, OSA Technical Digest Series (Optical Society of America, Washington, DC, 1995), pp 363-364

University of Calgary

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Contact: Dr. Jim Haslett (Head of Electronic's Department)

Background: The University of Calgary is a highly regarded university in North America for it's electrical engineering program. The excellence of its engineering program is due to the program, but also to in-house research capabilities. With over 40 graduate students, technicians, and post-doctorate researchers, the University of Calgary reaches out to encounter the new boundaries of microelectronics.

Research Topics

- High Temperature Precision CMOS Circuits for Oilfield and other Instrumentation
  - Trofimenkoff, Haslett, Aghtar, Akitt, Finvers, Sabouri, Upreti
- Design, synthesis and implementation of integrated digital signal processing (DSP) systems
  - Turner, Graumann, Wekel
- Analog CMOS circuits for precision position sensing
  - Haslett, Trofimenkoff
- Chopper stabilized CMOS amplifiers for instrumentation
  - Haslett, Trofimenkoff, Aghtar
- Signal Processing Electronics
  - Trofimenkoff, Dumitru
- High Frequency Circuit Design
  - Johnston, Kelly
- Synthesis and implementation of analog and digital filters for VLSI with emphasis on multidimensional image processing
  - Bruton, Chung, Kulach, Lam, Zhang
- Signal Processing Systems for Image Processing
  - Bruton, Cheng, Dilger
- CAD Design and Test of Temperature Controllers for Rapid Thermal Processing
  - Norman, Yu
- Artificial Neural Networks for Motor Control and Flux Estimation
  - Nowicki

- Structured Techniques and CAD Systems for MOS and GaAs VLSI Circuit Design
  - Gu, Du, Yu
- Intelligent Techniques and CAD Systems for Silicon and Hardware Compilation
  - Gu, Yu
- GaAs UHF MMIC Power Amplifier Design and Fabrication
  - Johnston, Rabjohn (BNR), McRory

Recent Publications:

L.T. Bruton, "On Potential Applications of 3D Space-Time Filters", Proceedings of IEEE International Symposium on Circuits and Systems. (Invited Paper), Atlanta, GA., May 1996

T. Chan, and B.A. Francis. "Design of Multi-rate Filter Banks by H-Infinity Optimization." IEEE Trans. on Signal Processing. vol. 43, no. 12, pp. 2822 - 30, 1995

B. Donaldson, M. Fattouche, and R. Donaldson. "In-Building Wireless Radio Channel Characterization Based on Energy Measurements and the Hilbert Transform" In Proceedings of IEEE Pacific Rim Conference on Communications, Computer and Signal Processing. Vancouver, B.C., 1995

A.K. Gupta, J.W. Haslett, and F.N. Trofimenkoff. " A Wide Dynamic Range Adjustable CMOS Current Mirror." IEEE Journal of Solid-State Circuits (In Press 1995)

J.W. Haslett, F.N. Trofimekoff, I.G. Finvers, F. Sabouri, and R. Smallwood. "High Temperature Electronics Using Silicon Technology." In Proceedings of International Solid-State Circuits Conference. 1995.

R.H. Johnston, "Antennas for Cellular and In-building Applications." Paper presented at TR Labs Technical Days, 20 pages, 1995

K.V.I.S Kaler,. A. Docoslis, N. Kalogerakis, and L. Behie. "A Micromachined Dielectrophonetic Filtration Device." IEEE Industrial Application Society. (In press 1995)

X. Liu, and L.T. Bruton, "High-Speed Systolic Ladder Structures of Multidimensional Recursive Digital Filters." IEEE Transactions on Signal Processing vol. 44, no. 4 (In press. 1995)

X. Liu, and L.T. Bruton. "Improved LDI Digital Filters Derived from Analog LC Ladder Filters." Signal Processing (Elsevier Science Publishers, Amsterdam), vol. 46, pp. 147 - 158, 1995.

R.D. Lopes, and R.M. Rangayyan. "3D Region-Based Filters for Noise Removal." In Proceedings of IASTED/IEEE International Conference on Signal and Image Processing, pp 424 - 427, 1995.

G. Panneerselvam, P.J.W. Graumann, and L.E. Turner. "Fast Fourier Transforms in FPGA's." In Proceedings of Third Canadian Workshop on Field Programmable Devices. 1995

J.A. Provine, L.T. Bruton. "3-D Model Based Coding - A Very Low Bit Rate Coding Scheme for Video-Conferncing". In Proceedings of IEEE International Symposium on Circuits and Systems 1996. accepted 1995.

V.M. Rao, B. Nowrouzian. "A Novel High-Speed Bit-Parallel Multiply-Accumulate Arithmetic Architecture." In Proceedings of SPIE Conference on Advanced Signal Processing Algorithm, Architectures and Implementations. 1995.

V.M. Rao, B. Nowrouzian. "Design and Implementation of Asynchronous Parallel Multiply-Accumulate Arithmetic Units." In Proceedings of 38th Midwest Symposium on Circuits and Systems. 1995

F. Sabouri, F.N. Trofimenkoff, J.W. Haslett. "A High Performance Calibration-Free Change-Balancing Analog-to-Digital Converter." IEEE Transactions on Instrumentation and Measurement. (In Press 1995.)

J.H. Satyanarayana, B. Nowrouzian. "Design and FPGA Implementation of Digit-Serial Modified-Booth Multipliers." Journal of Circuits, Systems, and Computers. (In Press, 1995)

H. Shu and T. Chen. "On Causality and Anticausality of Cascaded Discrete-Time Systems." IEEE Trans. on Circuits and Systems I: Fundamental Theory and Applications. vol. 43, no. 3

L.E. Turner, P.J.W. Graumann, S. Gibb "Rapid Hardware Prototyping of Digital Signal Processing Systems Using a Field Programmable Gate Arrays." In Proceedings of International Workshop on Field Programmable Logic. pp. 129 - 138. 1995

L.E. Turner, R.V. Kacelenga, P.J.W. Graumann. "FIR Digital Filter Design using Primitive Sections." Micronet Annual Workshop, presented in 1995.

University of Manitoba

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Contact: Witold Pedrycz (Professor, Associate Head - Computer Engineering)

Background: The University of Manitoba has a large research program within the microelectronics sector. A research staff of over 50 personnel comprises of technicians, professors, and graduate students delve into the areas of devices and circuits as they pertain to microelectronics.

Research Topics

Computer Communications Networks: where professors Witold Kinsner, Howard Card, Dave Blight, and Bob McLeod are in the forefront of data and signal compression using neural networks, wavelets and fractals, and fuzzy inference engines. The group has a genuine interest in VLSI design. This group works closely with TRLabs, Microelectronics Centre, National Semiconductor and MTS.

Computational Intelligence: Laboratory where professors Witold Pedrycz and Jim Peters are in the forefront of computational intelligence, pattern recognition, and intelligent control. The research embraces fuzzy set technology, neurocomputing and evolutionary computation. This group works closely with Bristol Aerospace, the Canadian Space Agency, and NRC Institute for Biodiagnostics.

Diagnostics for Microelectronics: where professors Doug Thomson and Greg Bridges are leaders in scanning probe microscopy and lattice gas automata. They have developed an electrostatic force microscope, and a scanning resistance microscope as leading edge diagnostic tools for microelectronics. They are developing a scanning near-field optic microscope for studying semiconductor lasers.

Recent Publications

D.C. Blight and R.D. McLeod, "Cyclic Routing in Wormhole Networks", IEEE Pacific RIM Conference on Communications, Computers, Visualization and Signal Processing, Victoria, Canada, 1995.

D.C. Blight and R.D. McLeod, "Reconfiguration and Routing in Defective WSI Processor Arrays", Seventh Annual IEEE International Conference on WSI, San Francisco, 1995

D.C. Blight and R.D. McLeod, "Elastic Neural Networks for FPGA Placement", International Workshop on Field Programmable Logic and Applications, Oxford, Sept. 1993

N.R.S. Simons and E. Bridges, "Application of the TLM method of two-dimensional scattering problems", International Journal of Numerical Modelling: Electronic Networks, Devices, and Fields, vol. 5, pp. 93 - 110, 1992

G.E. Bridges, R.A. Said, M. Mittal, D.J. Thomson, "High Frequency Pattern Extraction in Digital Integrated Circuits using Scanning Electrostatic Force Microscopy," Journal Vacuum Science and Technology - B, Vol. B - 13, pp. 1375 - 1379, 1995

G.E. Bridges, R.A. Said, D.J. Thomson, "Heterodyne Electrostatic Force Microscopy for Non-Contact High Frequency Integrated Circuits Measurement", Electronics Letters, Vol. 29, pp. 1442 - 1444, 1994.
H.C. Card, C.R. Scheider and R.S. Schneider, "Learning Capacitive Weights in Analog CMOS Neural Networks", Journal of VLSI Sig. Proc. Vol. 8, pp. 209 - 225

W. Pedrycz, "Fuzzy Sets Engineering", CRC Press, Boca Raton, Florida, 1995.

W. Pedrycz, "Fuzzy multi-models", IEEE Trans. on Fuzzy Systems, 4, 1996, pp. 139 - 148

B. Raharjo, J.F. Peters, R.D. McLeod, "Communicating Processes in Designing Asynchronous Circuits", IEEE Aerospace and Electronic Systems [to appear]

N. Simons and A. Sebak, "Application of the Transmission Line Matrix Method of the Analysis of Scattering by Three Dimensional Objects", IEE Proceedings, Part H, Vol. 142, pp. 319 - 325, 1995

K.L. Westra and D.J. Thomson, "The microstructure of thin films observed using atomic force microscopy", Thin Solid Films, 257, pp. 15 - 21, 1995.

University of Saskatchewan

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Contact: Office of Research Services

The Office of Research Services at the University of Saskatchewan has a service orientation, focusing on the needs of faculty, research staff and graduate students. The Office of Research Services is the primary liaison for national granting councils, for industry, and for private foundations that fund university based research.

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Background: The University of Saskatchewan is currently doing research in the Microelectronics fields with sponsors such as NSERC, MRC, SSHRC, ADF and TRLabs leading the way. Important collaboration is taking place with CMC. The University of Saskatchewan ranked 10th overall in North America for the quality of its Electrical Engineering program. This very credible placement according to the Gourman Report (1993) is an indication of the strong level of engineering skill resident at the university.

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Contact: Dr. John Long

Background: Based in Canada's largest city, the University of Toronto, is one of the largest universities in Canada, serving as a learning centre of excellence and as a first rate research facility for the needs of industry today. At the University of Toronto, a combination of corporate, federal, and research groups support a wide range of microelectronic research. Micronet and ITRC reside at the University of Toronto. The diversified research being conducted by graduate students and professors at this University combines the talents of a wide range of backgrounds. The University of Toronto offers researchers the room to work together to expand the microelectronic knowledge base as they continue probing the extensive microelectronics domain. Very significant advances have been made in RF chipsets using SiGe HBTs. Research at the University of Toronto is expanding to meet the needs of the microelectronic sector in Canada and beyond.

Research Topics

Field Programmable Arrays

- Field programmable arrays - architectures, and VLSI layout and circuit design for high speed;
- Field-Programmable Analog Arrays - the circuits, architecture and CAD tools that allow for the instant prototyping of analog circuits in a monolithic IC.
- Field programmable systems for rapid circuit prototyping and custom computer machines.
- Field-Programmable Gate Array Architecture - the study and improvement of FPGA logic block and routing architecture so as to increase their speed and logic density
- Computer-Aided Design Tools for Field-Programmable Gate Arrays - CAD algorithms specific to the differences in architecture that make FPGAs different from semi-custom ASICs
- Field-Programmable System architecture, applications and synthesis.
- Field-Programmable systems contain several FPGAs, interconnection chips and memory chips. They are useful for almost any digital task, yet need architectural improvements to increase their speed and density, and need specialized synthesis tools to be easily used.
- Architecture of FPGA devices
- Use of FPGAs in high-speed applications and development of design (synthesis) techniques for such applications.

BiCMOS

- Low voltage analog CMOS/BiCMOS circuits for telecommunication.
- Device design, modelling, fabrication including Heterojunction Bipolar transistors; BiCMOS compatible HV Devices; EEPROM cells.
- Low voltage analog CMOS/BiCMOS circuits for telecommunication.
- CMOS/BiCMOS compatible non-volatile semiconductor memories for telecommunication and portable electronic products.
- High speed/Low power mixed analog-digital circuits in silicon and gallium arsenide

- Development of the analog interface components required in wireless communication systems using a BiCMOS technology. Currently the analog components are the major limitation on the speed, power, and dynamic range of most wireless systems. Some of the components being developed include active LCR filters, LCR quadrature oscillators and demodulators, low-noise preamps, phase-locked-loops, etc.
- Mixed Digital/Analog Circuits

Communications and Converters

- High Speed Data Communication Circuits
- Sigma-delta A/D convertor
- Mixed analog/digital arrays.
- A/D & D/A Converters.
- Development of circuit synthesis tools suitable for the realization analog building blocks and systems. The ultimate goal of this program is to largely automate the realization of oversampling A/D converters. In order to realize these systems, it is first necessary to realize module generators for op amps, switched-capacitor filters, D/A's, etc.
- Development of infinite-impulse-response adaptive filters for applications such as 3-D sound and low-feedback teleconferencing.
- Digital Signal Processing of Oversampled Signals
- High performance and accurate arithmetic using logarithmic number system.
- Digital filters operating on oversampled signals

Other Circuits

- Semiconductor Memory Circuits
- Common Memory ATM Switches - logic enhanced memory structures to support the switching of high speed ATM data packets.
- Data Compression ASICs - algorithms and VLSI architectures for both still images and full-motion video.
- Mixed Technology VLSI Design - given multiple technologies in which to fabricate transistors how does one decide where they should be used to optimize speed, power, etc. in a ULSI system.
- Programmable and Adaptive Filters
- Circuit theory and design featuring techniques which merge voltage- and current-mode techniques to attain high-frequency operation.
- Filter theory and design techniques including the integration of these into a computer-aided filter design tool, and the application of programmability and tunability to integrated filters.
- The application of filter and circuit techniques to create a complex-signal, bandpass,
- Power/High-Voltage devices and circuit designs for telecommunication, automotive and other power electronic applications.

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Contact : R. Pan Agathoklis (Head of Electrical and Computer Engineering)

Background: With the new infrastructure, the University of Victoria is proving itself still to be a campus for excellence in research. With the new building, new labs and equipment means that the researchers at the University of Victoria continue progress in their work into advancing the knowledge base of microelectronic technology. The facility is doing some advanced work on MMIC devices for communications applications.

Research Topics

Analysis, design, and realization of 1-D and 2-D digital filters including adaptive filters.

Application of 1-D and 2-D digital filters to communications, remote sensing (e.g. bathometry), medical imaging, and forestry.

Asynchronous transfer mode (ATM) switching architecture: ATM switching architectures performance (bandwidth, delay, blocking, number of connections, hardware complexity, etc.). Potential applications (private network, LAN switching, public network, etc.).

Design and fabrication of CCD support circuits

Design of delta-doped quantum well structures and devices

Design and fabrication of wide dynamic range circuit sensors and circuits

Design and fabrication of mixed-mode GaAs ICs with emphasis on signal processing and neural network

Design and fabrication of GaAs CCDs and detectors in conjunction with TRIUMF

Developing new inner-product processors (i.e. a + b x c) for fixed-point operations at double precision and at double the speed of an ordinary multiplier/accumulator. This concept is being extended to handle floating point data using pipelined data path processor architectures.

Developing two techniques for obtaining processor arrays structures given an iterative algorithm. One technique is based on computational geometry concepts and is applicable to many DSP algorithms. The other technique is based on the z-transform method and is suited to digital filter algorithms.

Fast algorithms for decoding technique.

Low power, low cost devices for wireless communications.

Modelling, design and optimization of GaAs CCDs and heterojunction CCDs

VLSI implementation of digital filter algorithms: (a) direct form and cascaded implementations of 1-D and multi-D IIR filter, (b) state-space implementations, © multi-rate digital filters (decimators and interpolators), and (d) finite word effects for fixed- and floating-point data formats.

VLSI implementation of error-control coding devices.

VLSI implementation of 1-D and 2-D digital filters and related DSP modules.

As an integral part of research in M-DSP, advanced methodologies for the design and analysis of M-D digital filters, M-D analysis/synthesis filter banks and M-D regularization filters are being sought with much emphasis placed on real-time processing capability. Specific research projects that are presently being carried out are as follows:

- design of 2-D filter banks with low reconstruction delay and with hexagonal support regions;
- application of above filter banks to image coding and transmission;
- design of multi-parameter 2-D regularization filters;
- application of above filters to image restoration problems;
- design of very-low-order 2-D FIR filters for real-time image enhancement;
- stable reduction and simplification of 2-D filters.

Recent Publications

L. Chen, M. Wedlake, G. Deliyannides and H.L. Kwok, "Hybrid architecture for analogue neural network and its circuit implementation," IEE Proc. -Circuit Devices, Vol. 143, No. 2, April, 1996, pp. 123 - 128

H.L. Kwok, L. Chen, and A. Antoniou, "Detector charge-sensing using an integrated GaAs operational amplifier." Nuc. Instru. and Meth. A322 (1995), pp. 372 - 375

L. Chen, H.L. Kwok, "Design and fabrication of a GaAs weight-summation circuit (WSC) for use in neural networks," Int J. Electronics, 1996, Vol. 81, No. 2, 177 - 186

University Of Waterloo

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Contact: Wayne Mervin Loueks (Associate Professor)

Background: The University of Waterloo has an exeellent research program which includes over 50 individuals in the microelectronics sector alone. Research ranges from BiPolar/BiCMOS work to the advaneement of Silicon Germanium (SiGe) technology. The University of Waterloo prides itself on the outstanding work being done by its finest professors and Waterloo's own graduate students who are in high demand at the completion of their studies.

Research Topics

Circuit partitioning techniques, suitable for use in the parallel simulation of large systems (including, but not limited to, digital eircuits).

Amorphous semiconductor technology and processing; film deposition and characterization, thin film transistors, optical and x-ray sensors, stability issues.

Bipolar and CMOS device design and fabrication

Bipolar transistor modelling such as emitter resistance, current gain fall off, temperature dependence

CMOS Oversampled and Pipelined A/D, D/A Converters

Compound semiconductor devices; device fabrication and characterization, ballistic transport, low-dimensional effects, strained layers, single-electron devices.

Develop design methodologies and corresponding DA tools for the above.

Development of low noise micropowered interface circuits for integration of microsensors for biomedical applications.

Development of semiconductor devices for detection of magnetic, thermal, optical, and mechanical signals, and corresponding computer aided design tools.

Device physics, and in particular, a study of interaction of mechanical (e.g. strain), thermal, optical, and magnetic signals on carrier transport.

Low Complexity Reed-Solomon Codec bit-serial architectures, rate-adaptive codes.

Parallel simulation techniques, suitable for complex digital circuit simulation.

Research on the development of new fabrication technology (CMOS/CCD).

Research on BiCMOS semiconductor device design and modelling.

SiGe heterojunction technologies that are more readily compatible with standard Si Process. Ge ion-implantation and vacuum deposition with in site low energy ion-bombardment are two approaches under study.

Silicon-Germanium technology

Silicon-on-Insulator based bipolar/BiCMOS. Most of the focus had been on bipolar (polysilicon emitter types)

Simulation, fabricating and testing of the above circuits and systems using current and next generation technologies.

Study the effect of temperature, device scaling and voltage scaling on performance.

The development of co-simulation techniques and applications. (Co-simulation involves the simulation of systems combining both hardware and software subsystems.)

The development of architectures and applications for parallel computing.

The design of novel state-of-the-art digital and mixed analog/digital circuits and systems including CMOS, Bipolar and BiCMOS

Thin film materials for ICs and microsensors

VLSI Architecture for Digital Signal Processing, Optimization, CAD.

Recent Publications

"RF Circuits and Systems," International Symposium on Circuits and Systems (ISCAS), Leung, B., Tutorials pp. 397-444, May 1996.

"Passive Sigma-Delta Modulator with Built-In Passive Mixer for Mobile Communication,"Leung, B., and F. Chen, invited talk at Advances in Analog Circuit Design (AACD'96), Lausanne Switzerland, April 1996.

"A 0.25mW, 13bit passive sigma-delta modulator for a 10MHz IF input,", Chen F. and B. Leung, International Solid State Circuit Conference Digest of Technical Papers (SSCC), pp.58-59, February 1996.

"A 1.95V, 0.34mW 12bit Sigma-Delta Modulator with Local Feedback Loops,", Au, S., and B. Leung, Custom Integrated Circuits Conference (CICC), Section 20.1.1-20.1.4, May 1996.

"A High Resolution Multibit Sigma-Delta Modulator with Individual Level Averaging", Chen F., Leung B., IEEE Journal of Solid State Circuits, pp.453-460, vol 30, No. 4, April 1995 .
"BiCMOS Circuits for High Speed Current Mode D/A Converters", Chen F., Leung B., IEEE Journal of Solid State Circuits, pp.923-934, vol 30, No. 8, August 1995

"A Class-AB High-speed Low-power Opamp in BiCMOS Technology", Sen S., Leung B., accepted to be published in IEEE Journal of Solid State Circuits, September 1996.

"A Class-AB High-speed Low-power Opamp in BiCMOS Technology", Sen S., Leung B., Proceedings of Bipolar Circuits and Technology Meeting (BCTM'95), October 1995, pp. 19-22, Minneapolis.

"Simulation of Queueing Systems in FPGAs," P. Chong and W.M. Loucks, Proceedings of the Fourth Canadian Workshop on Field-Programmable Devices, 6 manuscript pages, Toronto, ON, May 1996.

"Memory Management Techniques for Time Warp on a Distributed Memory Machine," B.R. Preiss and W.M. Loucks, Proceedings of the 1995 Workshop on Parallel and Distributed Simulation (PADS), pages 30-39, Lake Placid, NY, USA, June 1995.

"Efficient Experimentation of a Primitive Root in GF(2m)," Wu. H., and M.A. Hasan, IEEE Trans. Computers, 32 MS pages, Accepted, May 1996.

"Efficient Experimentation using Dual Basis," Wu, H., and M.A. Hasan, accepted, 18th Biennial Symp. Communications, Kingston, ON 1996.

"VLSI Implementation of Inversion in GF(2m)," Pichora, M., and M.A. Hasan, accepted, 18th Biennial Symp. Communications, Kingston, ON 1996.

"A Low Power Radix 2 Division Algorithm with Minimum Add/Sub," Farag, F.N., M.A. Hasan, and M.I. Elmasry, accepted, SPIE, Denver, 1996.

"Architecture for a Low Complexity Rate-Adaptive Reed-Solomon Encoder," Hasan, M.A., and V.K. Bhargava, IEEE Trans. Computers, pp. 938-942, July 1995.
"Double-Basis Inversion in GF(2m)," Hasan, M.A., Canadian Conference on Electrical and Computer Engineering, pp. 229-232, 1995.

"Division-and-Accumulation in GF(2m)," Hasan, M.A., Canadian Conference on Electrical and Computer Engineering, pp. 233-236, 1995.

"Shift-Register Synthesis for Multiplicative Inversion over GF(2m)," Hasan, M.A., IEEE ISIT, p. 95, 1995.

University of Windsor

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Contact: Dr. G.A. Jullien, Director of Microelectronics Research Group

Background: The University of Windsor is a mid-sized, comprehensive research and teaching university situated on the Canada/U.S. border, right in the heart of the Great Lakes region. The University has significant collaborative research projects with industry, including the largest joint University-Industry centre in Canada at the University of Windsor/Chrysler Canada Ltd. Automotive Research and Development Centre. Microelectronics research at the University is carried out within the Department of Electrical Engineering. Currently there are over 40 faculty and graduate students working in the Microelectronics Research Group. The university has been active in the promotion of industry collaboration and is constantly interacting with interfaces established by government and industry.

Major Research Areas

- The design and microelectronic implementation of high performance arithmetic units.
- Microelectronic implementation of high performance digital signal processing.
- Digital Signal processing algorithms optimized for microelectronic implementation.
- Microelectronics implementations of artificial neural networks.

Research Topics

Algorithms and architectures for implementing real-time DSP algorithms. Particular applications to data stream video-rate processors using bit-level systolic arrays.

Analysis, design, and microelectronic implementation of 1-D and 2-D digital filters, and digital decimators and interpolators, for communication, video, and HDTV applications.

Application of modern algebra to VLSI DSP algorithms and their implementation on silicon.

Architectures, training and implementations of Neural Networks. Particular interest in special pattern recognition techniques using the 'Brain Model', and in hybrid neural systems.

Computer arithmetic techniques oriented towards pipelined high-throughput processors. Particular interest in the use of finite algebraic techniques for linear bit-level pipelines.

Current interest in special dynamic pipelines and transistor tree architectures for matching processor speed with required data rate in a variety of advanced processing technologies, and in low critical path binary arithmetic building blocks.

Design and microelectronic implementation of real-time adaptive digital filters for noise cancellation and system modelling applications.

Design and microelectronic implementation of digital neural systems and fuzzy neural systems for pulse radar detection, pattern classification, and system control applications.

Design of neural networks with an integrated photosensitive array

Design and microelectronic implementation of low-frequency digital oscillators for high-precision signal generation and communication applications.

Design and implementation of various digital circuits for hybrid and digital Neural Network architectures using 3.0 um and 1.2 um CMOS processes.

Design and implementation of various Analog Circuits for hybrid Neural Network architecture using 3.0 um and 1.2 um CMOS processes.

Digital signal processing architectures with systolic structures

Intelligent sensors based on neural networks used for process control applications requiring non-contact measurements

On-board learning strategies and architectures for neural networks

Recent Publications

Z. Wang, G.A. Jullien, W.C. Miller, "An Efficient Tree Architecture for Modulo 2n+1 Multiplication", Journal of VLSI Signal Processing (Accepted for publication July 1996)

H.E. El-Gamal, J.J. Soltis, M. Ahmadi, "Order Reduction Technique Using the Chebyshev Polynomial and Its Application In Digital Filter Design", Proceedings of IEE Part G, Circuits, Devices and Systems, Vol.142, No.1

A. Nosratina, A. Mazinani, V. Ramachandran, M. Shridhar, "A High-Swing, High Drive CMOS Buffer", IEEE Proceedings, Pt. G, Circuits, Devices, and Systems, Vol. 142, No.2

H. Safiri, M. Ahmadi, H. Nivi, "Classification of Paint on Metallic Surfaces Using spatial Domain Analysis of Laser Images", Journal of Computers in Electrical Engineering, Vol. 21, No. 6

J.C. Czilli, P. Zhou, G.A. Jullien, W.C. Miller, "BiCMOS Current Steering Pipeline Circuit Technique", IEE (UK) Electronic Letters, Vol. 30, No. 24

Z. Wang, G.A. Jullien, W.C. Miller, "Comments on 'On Asymmetrical Performance of Discrete Cosine Transform'", IEEE Trans. on Digital Signal Processing, Correspondence, Vol. 42, No. 11

Z. Wang, G.A. Jullien, W.C. Miller, "Interpolation Using the Discrete Sine Transform with Increased Accuracy: Reply", IEE (UK) Electronic Letters, Vol. 30, No. 6

Recent Conference Papers

V. Dimitrov, S.S. Emamchie, G.A. Jullien, W.C. Miller, "A Near Canonic Double-Base Number System (DBNS) With Applications in Digital Signal Processing", SPIE Conference on Advanced Signal Processing Algorithms, Architectures, and Implementation VI

H. Djahanshahi, G.A. Jullien, W.C. Miller, M. Ahmadi, "Neural-based Smart CMOS Sensors for On-line Pattern Classification Applications", (Invited Paper) IEEE International Symp. on Circuits and Systems (ISCAS'96)

H. Djahanshahi, M. Ahmadi, G.A. Jullien, W.C. Miller, "Design and VLSI Implementation of a Unified Synapse-Neuron Architecture", Proc. of the Great Lakes Symposium on VLSI, GLSVLSI'96

W. Luo, G.A. Jullian, N.M. Wigley, W.C. Miller, Z. Wang, "An Array Processor for Inner Product Computations Using a Fermat Number ALU", Proc. of the 1995 Int. Conf. on Application Specific Array Processors

H. Safiri, M. Ahmadi, V. Ramachandran, W.C. Miller, "Design of Finite Wordlength 2-D Recursive Digital Filter using All-Pass Building Blocks", Proc. of 1995 Midwest Symposium on Circuits and Systems