The Wireless Cowboys at Home on the Frequency Range

They are self-professed analog 'range riders' - as designers of the physical, transistor layer of the wireless system of the future. Seemingly at odds to the uninitiated versed in the belief that 'digital is better', analog wireless design is a cost and power efficient contribution to novel circuit designs evolving to a point in the future where entire wireless systems will be present on single 'chips'.

"To do wireless economically, many types of 'radios on a chip' are needed," says TRLabs Adjunct Scientist Dr. Jim Haslett. "In a world where switches, filters,amplifiers and the like tend to be off-chip and therefore more expensive and less reliable, getting high performance [> 10 GHz, low power, programmable] wireless building blocks onto a single chip and speaking the same language [i.e. analog/digital conversion] is a sizeable technological challenge – but is a key to low cost systems."

Haslett notes that the integrated circuit designs (RFIC) of the future will remove the technological barriers that have constrained wireless ubiquity. "If we can unite systems and functions onto single chips at higher frequencies that achieve higher bandwidth, we open the door to an era of cheap, small and fast products of virtually any form or function. Taken to its extreme, we may even see a day where we drop 'smart dust' to locate someone lost in the wilderness – hundreds or thousands of tiny wireless system sensor communicators that send messages back to trackers."

An NSERC, iCORE, University of Calgary, and TRLabs $3.42 million investment partnership has created an Industrial Chair for Dr. Haslett, and the establishment of the Wireless Science and Technology Initiative to explore RFIC design. System on Chip design is a strategic goal; incremental innovation will involve the design of novel circuits that provide efficiency and better performance, RF System on Chip design, and ultimately integrated System on Chip design incorporating computer, digital, and RF systems on a single chip. Along the way innovation will take place in the form of design of leading edge components, from low noise amplifiers to frequency synthesizers.

THE Network-
Stepping stones

DR JAMES HASLETT

WIRELESS SCIENCE AND TECHNOLOGY INITIATIVE

TRLabs/iCORE/NSERC Industrial Research Chair
Electrical and Computer Engineering
University of Calgary

Dr Jim Haslett leads a research program called the Wireless Science and Technology Initiative. To develop the research team, Dr Haslett has received an iCORE Industrial Chair Establishment (ICE) grant from iCORE of $200,000 per year for five years for a total of $1 million dollars.

EXECUTIVE SUMMARY

This five-year Industrial Research Chair program, funded by TRLabs, iCORE and NSERC, is focused on developing, in conjunction with the TRLabs Wireless Research Center in Calgary, a sophisticated wireless radio frequency (RF) Integrated Circuit design and test capability, with Dr Jim Haslett as the group leader. The main intention of the research program is to develop the expertise required to design novel new devices, circuits and systems for 3rd and 4th generation wireless products of interest to the industrial sponsors of TRLabs, and to the wireless community in general.

The research program began in May of 2002, and in the ensuing 11 months, a team of four PhD's, eight MSc's and two postdoctoral fellows has been assembled by Dr Haslett to carry out the chair mandate. Close collaboration with staff scientists at TRLabs, and extensive collaboration with other researchers and industrial sponsors has resulted in an excellent list of accomplishments for the first year of the chair program.

The student team currently consists of four PhD students, three holding NSERC/iCORE scholarships; and eight MSc students, three holding NSERC/iCORE scholarships, and a fourth holding an NSERC Industrial Scholarship. Two of the students have direct industrial RF design experience, and all have become proficient in RF Integrated Circuit design in a variety of fabrication technologies, including CMOS and Silicon Germanium BiCMOS.

The RFIC Design laboratory uses state-of-the-art design, simulation and layout software tools, and a sophisticated test laboratory is in use at TRLabs. Excellent infrastructure resources provided by the Canadian Microelectronics Corporation (CMC) are complemented by an expanded Very Large Scale Integration laboratory, a new RF laboratory, a new secure System-on-Chip laboratory and a Clean Room Facility, house in the new Information and Communication Technology (ICT) and Calgary Centre for Innovative Technology (CCIT) buildings on the University of Calgary campus.

Dr Haslett and the research team have been successful in bringing in significant external funds to complement the $600,000 annual chair budget. In the past 11 months, an additional $244,368 has been obtained by Dr Haslett as principal applicant, to support the research program, excluding the student scholarships which amount to an additional $209,000 per year. Other funding has been obtained with Dr Graham Jullien, as outlined in the report.

During the year, 23 new RFICs designed by the research group were fabricated through the CMC, and the results published in a variety of conferences and journals. Two new patent applications were filed through TRLabs. A national award and a local award were received by the students for some of the work. A number of new collaborative research projects were initiated, and a team of 10 principal researchers, including Dr Haslett, prepared a Canada Foundation for Innovation (CFI) grant application to provide additional infrastructure to support the research programs.

RESEARCH GOALS AND OBJECTIVES

This Industrial Chair Program in Wireless Science and Technology (WISTI) was initiated on May 1st, 2002, for a five-year period. The main research goals and objectives outlined in the chair proposal focused on developing, in conjunction with the TRLabs Wireless Research Center in Calgary, a state-of-the-art wireless RF devices, circuits and systems design and test capability, with Dr Jim Haslett as the group leader. The main thrust of the new research program was to develop new and novel techniques for providing operational flexibility, low noise, and low power devices for the next generations of wireless products, of interest to the industrial sponsors of TRLabs, and to the wireless community in general.

WISTI Strategy:
The WISTI initiative was targeted to contribute to the development of a critical mass of RF researchers in Alberta with a primary focus on the device and circuit aspects, in cooperation with researchers working on overall system aspects at the University of Calgary, in the TRLabs Wireless Research Centre in the Discovery Place Research Park adjacent to campus, and at the University of Alberta. It was envisaged that the enhanced wireless RF research activity would provide a focal point for the training of highly qualified personnel that the industry needs as it moves into the next generation of wireless systems.

WISTI was intended to provide a capability to address the problems faced by Alberta and Canadian industry in generating new products using new technologies for the wireless marketplace. The TRLabs industrial sponsor consortium includes many of the major players in the wireless communications industry, providing an excellent opportunity to transfer the technology directly to the industry in a timely fashion. The critical mass was also expected to attract excellent graduate students, visitors and postdoctoral fellows from around the world.

To enhance the chair research program, an additional academic staff member was to be hired into electrical engineering from supporting fields such as integrated optics, nanoscale fabrication technology, quantum electronics, multimedia, or low power systems.

Accomplishments to Date:
The program has had a very good start, and after the first 12 months, a research team of four PhDs, eight MScs and two postdoctoral fellows is in place. Several of the students have won local, national and international awards and scholarships. A large number of RF integrated circuits have been designed, with a number of these fabricated and tested. The results have been disseminated to the industrial sponsor, and several journal and conference papers have been published. Two patents have been filed, and other papers are under preparation, under review or accepted for presentation at conferences in 2003.

Dr Haslett has also been successful in attracting additional funds from external agencies to support the research. This includes, with Dr Haslett as principal applicant, $67,700 from the Canadian Microelectronics Corporation (CMC) for integrated circuit design workstations and server, over $100,000 in chip fabrication grants from the CMC to support the RFIC design group in 2002-3, $39,383 from NSERC in the form of an equipment grant in March of 2003, and a $55,000 portion of Micronet funding with Graham Jullien as principal investigator in 2002-3. An additional software donation was received by Dr Haslett from Applied Wave Research in the US, to provide Microwave Office software to 20 students, valued at a commercial value of $28,800 US per copy, to support the graduate teaching and research.

In addition, $300,000 was allocated to Drs Haslett and Jullien from the Calgary Centre for Innovative Technology (CCIT). Research Group budget

THE TRLABS INDUSTRIAL SPONSOR CONSORTIUM INCLUDES MANY OF THE MAJOR PLAYERS IN THE WIRELESS COMMUNICATIONS INDUSTRY, PROVIDING AN EXCELLENT OPPORTUNITY TO TRANSFER THE TECHNOLOGY DIRECTLY TO THE INDUSTRY IN A TIMELY FASHION.

(Gérard Lachapelle, Group Director) to establish new RF Lab and Clean Room Facilities, in July of 2002. Dr Haslett is currently in the process of supervising the construction of a new RF design and test lab in the CCIT facility. A new RF shielded enclosure was constructed in March and April of 2003, and has just been certified. Drs Haslett and Jullien have also been working toward a major expansion of the VLSI design facilities in the new Information and Communications Technology (ICT) building, and in CCIT. A second VLSI lab has been constructed in ICT, and a secure System-on-Chip (SOC) facility and Integrated Circuit Design Lab have been constructed in CCIT and are now operational. A Canada Foundation for Innovation (CFI) grant application has been submitted to provide additional equipment for these labs, with Dr Jullien as principal applicant, and with 15 other researchers involved. Dr Haslett is one of 10 principal researchers on that application.

At TRLabs, a new wide ranging collaborative research program in home technologies has been initiated, with financial support from new industrial sponsors, and from Western Diversification. Dr John McRory is leading a CFI grant application to support the research, and Dr Haslett is a principal researcher on that application as well.

In summary, the chair program is off to an excellent start, the team is largely in place, and infrastructure is being established to support the research program.

RESEARCH PROJECTS

Quite a number of research projects are currently under away, most targeted at developing building blocks for wireless transceiver systems, with applications in wireless local area networks, optical communications, biomedical monitoring, home technologies, and wireless location as examples.

Development of General RF Integrated Circuit Design Expertise

During the past year, Dr Haslett's research group has been developing expertise in the design, fabrication and testing of RF wireless circuit building blocks, in a variety of state-of-the-art fabrication technologies, for RF transceiver applications in the one to 20 GHz frequency range. Since many of the team members are new, and since the successful design, fabrication and testing of state-of-the-art RF integrated circuits is very challenging, the first year has involved a steep learning curve for many of the team members. The group is becoming proficient in the design of low noise amplifiers, mixers, voltage controlled oscillators, phase locked loop frequency synthesizers, filters, and other transceiver building blocks in silicon-germanium (SiGe) BiCMOS and deep submicron CMOS technologies, and this expertise can now be applied to several research projects as outlined below.

Realizing Fully Monolithic Transceivers in CMOS Fabrication Technology

The major challenge facing the wireless industry at present is to economically realize all required transceiver circuit functions on one silicon substrate (a monolithic realization), and to provide programmability to accommodate the various transmission standards encountered. This will reduce the cost of production very significantly, as well as miniaturizing the circuitry. Miniature low power circuits will open up the possibility of many new applications in the biomedical and other areas.

In order to achieve fully monolithic BiCMOS and CMOS circuits in the five to 20 GHz range, and to achieve maximum functional flexibility, the research group is working in several areas.

High Frequency Modeling of RF CMOS and Bipolar Transistors

Dr Haslett has published a number of papers in the area of the high frequency modeling of MOS devices, using tractable models suitable for hand analysis of small circuits such as those encountered in the RF building block research. With the widespread use of silicon-germanium bipolar high frequency transistors, similar RF characterization needs to be carried out. A great deal of activity is currently ongoing in the industry to provide sophisticated computer-aided design models for these devices. Dr Haslett's group has developed approximate analytic models for hand analysis of analog RF circuits, along with the development of a detailed understanding of current state-

of-the-art computer-aided models such as the Berkley BSIM4 Model, and the RF Bipolar transistor model high frequency scattering parameters. Dr Haslett's research group has ported CMOS 0.18 micron technology models from the Cadence Spectre RF modeling program to Cadence's new PSPICE modeling program that runs on PC platforms. This enables graduate students and others to use PCs for modeling the sophisticated processes rather than requiring a high level Unix workstation and several millions of dollars (one complete seat of Cadence software costs US $3.5 million) to perform basic circuit simulations.

Quality Factor Enhancement of Passive on-chip Spiral Inductors

One of the major impediments to achieving fully monolithic low cost transceivers in the industry today relates to the poor quality of on-chip passive components, and the worst of these is the spiral inductor. Researchers throughout the world have tried a myriad of solutions, but no real success has been achieved without expensive additional fabrication steps in the manufacturing process. Initial work by our group involved the development of a detailed understanding of the modeling and design issues involved, and more recently a technique to optimize the design of these inductors using the accepted approach to fabrication was developed and published. However, only marginal improvements are achievable with this approach, and a more dramatic solution is needed.

A possible solution for certain applications is being explored by the team, involving the use of a flux compensating second inductor mutually coupled to the main component, and driven in such a way as to enhance the quality factor electronically. A simple CMOS solution has been demonstrated experimentally, and a patent application has been filed through TRLabs. Detailed noise, distortion and stability analyses are under way. The circuit has interesting applications in filtering, and preliminary designs look promising in simulation.

The Gigabit Radio RFIC Project

The experience gained in the fundamental research is being applied to a new large integrated circuit design project that we have initiated at TRLabs. The hostility of the wideband radio channel imposes severe multipath and intersymbol interference (ISI) that must be overcome in order to send data successfully. A novel new architecture for a very high-speed wireless local area network (LAN) system has been designed by Dr Grant McGibney, a TRLabs Staff Scientist, over the past three years. Mitigation of these effects is accomplished by using digital signal processing (DSP) techniques to predistort/equalize transmitted data before/after passing through the wireless channel. To minimize the power consumption and complexity of the terminals, the DSP functionality is placed solely in the basestations of the network. The remote terminals are left as relatively simple devices consisting of a direct conversion receiver and simple comparators for analog/digital conversion.

The goal of this project is to produce a Radio Frequency Integrated Circuit (RFIC) which implements the functionality of a Gigabit Radio simple terminal. Initial research has concentrated on designing the RF low noise amplifier LNA), direct down conversion mixer, and voltage controlled oscillator (VCO) that will form part of the receiver frequency synthesizer. These projects push the technology right to the limits, and so far we have had partial success.

Integrated Optics and Optical Fiber Communication Systems

This project uses an RF logarithmic compression amplifier, along with a Hilbert Transformer and several other components, to reduce chromatic dispersion in optical fiber networks by generating a single-sideband modulated optical carrier. A first generation compression amplifier with a four GHz bandwidth has been successfully designed, fabricated and tested in collaboration with Nortel Ottawa using the NT 25 bipolar fabrication process, and the next generation logarithmic amplifiers have been designed and fabricated in silicon-germanium, through a new process made available to us by the Canadian Microelectronics Corporation, MOSIS and IBM Corporation. We are currently waiting for these chips to be returned for testing. The initial design has won a National Award in June of 2002, and the details have been published in the IEEE *Journal of*

Solid State Circuits and elsewhere. A patent application has also been filed.

The next major challenge is to produce a monolithic Hilbert Transformer, and this project is currently under way.

Self-Configuring RF Antennas and Millimeter Wave Systems
The lab has initiated a collaborative project with Dr Michal Okoniewski and Dr Ron Johnston, relating to the use of RF switches to electronically reconfigure antennas and other microstripline elements. Initial results are promising, and this research is ongoing, with applications in wireless navigation and location as well as in spatially selective communications.

These collaborative projects involve the application of RF wireless systems and nanotechnologies to biomedical and other applications, where we, along with a number of other University of Calgary researchers in electrical engineering, geomatics, mechanical engineering and medicine, are uniquely poised in Canada to make significant breakthroughs. Areas include a new generation of lab-on-a-chip diagnostic systems for a variety of detection applications.

System-on-Chip (SoC) Research
These projects involve the integration of wireless RF cores for use in the newly established SOC (System-on-a-Chip) laboratory, to allow the rapid design of sophisticated systems in monolithic form for a variety of applications. Our VLSI group is one of three Canadian lead clients for CMC on the Bluetooth SoC platform that will eventually be distributed to 21 Canadian universities. Our role is to take the Bluetooth digital IP core through the design cycle. Our RF group is also investigating a variety of products for the RF transceiver portion that would provide a complete and reconfigurable Bluetooth wireless transceiver system.

RF MicroElectroMechanical Systems (MEMS)
We are collaborating with Dr Graham Jullien, Dr Michal Okoniewski and TRLabs to combine RF MEMS devices designed by their research groups with RF integrated circuits designed by our group, to build unique new devices for several new applications ranging from wireless navigation and location to health related devices.

RESEARCH TEAM

TEAM LEADER	AWARDS
Jim Haslett	President's Circle Award, Teaching Excellence

COLLABORATORS	TITLE
Graham Jullien	iCORE Chair in Advanced Technology Information Processing Systems
Michal Okoniewski	CRC Chair in Electromagnetics

OTHER TEAM MEMBERS	RESEARCH TOPICS
John McRory	TR*Labs*
Bob Davies	TR*Labs*

POSTDOCTORAL FELLOWS	TOPIC	AWARDS
Hua Yan	RF Board Level Systems, Self-Configuring Antennas	
Vijay Devabaktuni	RF CAD Systems and Modeling	NSERC Postdoctoral Fellowship

PHD STUDENTS	TOPIC	AWARDS
Chris Holdenried	Optical Data Transmission Circuits and Systems	NSERC PGS-B, iCORE Graduate Student Scholarship, JB Hyne Research Innovation
Holly Pekau	SubSampling Mixers for Next Generation Wireless Transceivers	
Bogdan Georgescu	Transformer Based On Chip Spiral Inductor Q Enhancement	NSERC PGS-B, iCORE Graduate Student Scholarship
Rob Randall	CMOS Monolithic Power Amplifier Linearization Schemes	NSERC PGS-B, iCORE Graduate Student Scholarship
Ahmed Youssef	Analog RF Front End Circuits for Wireless LAN	

MSC/MENG STUDENTS	TOPIC	AWARDS
Josh Nakaska	Wireless LAN Frequency Synthesizers	NSERC Industrial Scholarship
Jim Kulyk	Monolithic Q-Enhanced Filters	
Damon Holmes	RF Power Amplifiers	NSERC PGS-A, iCORE Graduate Student Scholarship
Ken Townsend	Wireless LAN Vector Modulator	NSERC PGS-A, iCORE Graduate Student Scholarship
Cavell Li (part time)	Active Inductors	
James Quan (part time)	High Linearity Programmable Gain Amplifiers for Baseband Applications	
Jonathan Yeboah	Cellular Neural Networks	
Stephen Tseng	Coursework MEng.	

COLLABORATIONS

RESEARCH COLLABORATIONS:

Research collaborations are currently being carried out with the following individuals:

Dr Graham Jullien
Electrical and Computer Engineering, University of Calgary
Dr Jullien and Dr Haslett are collaborating on several projects, including a high data rate wireless LAN with TRLabs, and on analog computational schemes with Micronet.

Dr Michal Okoniewski
Electrical and Computer Engineering, University of Calgary
Dr Okoniewski and Dr Haslett are collaborating on several projects, including self-configuring antenna and other micostripline devices, plus RF MEMS devices for those applications.

Dr Wael Badawy
Electrical and Computer Engineering, University of Calgary
Dr Badawy and Dr Haslett are collaborating on the Bluetooth RF SoC platform from the Canadian Microelectronics Corporation.

Dr John McRory
TRLabs
Dr McRory and Dr Haslett are collaborating on several projects, including RF Power Amplifier Design, Spiral Inductor Q-Enhancement Techniques, and Home Technologies.

Dr Bob Davies
TRLabs
Dr Davies and Dr Haslett are collaborating on several projects, including Optical Data transmission systems, and home technologies.

Collaboration discussions have been initiated with the following individuals:

Dr Christian Schlegel
University of Alberta
Dr Schlegel and Dr Haslett are are planning on initiating research into analog circuit interfaces for signal processing systems.

COLLABORATIONS WITH INDUSTRY

TRLabs and its Industrial Sponsors (Samsung, Nortel)
TRLabs is the industrial sponsor of the research chair, and, as such, most of the research projects that we are pursuing will be of interest to their industrial sponsors. Our research projects are vetted and reviewed each year by a committee made up of sponsor representatives and TRLabs staff. We also have direct collaboration with some of the sponsors, as indicated below.

A. J. Bergsma, and R.D. Beards
Nortel Ottawa
Chris Holdenried, a PhD candidate under Dr Haslett's supervision, has been working with researchers at Nortel to design a wideband true logarithmic compression amplifier for optical fiber communications applications. The designs are successful, and the next project involves the design of an accompanying Hilbert Transformer.

SiWorks
Calgary
Dr Ivars Finvers, a former PhD student of Dr Haslett's, is now one of the members of this semicustom integrated circuit design house located adjacent to the university in the research park. He currently co-supervises one of Dr Haslett's PhD students. Another SiWorks employee, James Quan, is an MEng thesis-route student under Dr Haslett's supervision.

Dalsa Semiconductor
Ontario
Drs Jullien, Okoniewski and Dr Haslett are collaborating on the development of an RF MEMS process that is of interest to Dalsa, a chip manufacturing company in Ontario.

Multidiscipline or Multi-Institutional Partnerships: Canadian Light Source
University of Saskatchewan
Dr Haslett is a potential user of the Canadian Light Source CFI Initiative.

Dr Gérard Lachapelle, and Dr Elizabeth Cannon
Geomatics, University of Calgary
Drs Cannon and Lachapelle are collaborators on the CFI grant application currently being led by Dr Jullien. We plan to work on self-configuring antennas, with applications to wireless location. At a later time, it is anticipated that custom integrated circuits will be designed by our group for these applications.

Dr Arief Budimann
Mechanical Engineering, University of Calgary
Dr Budimann is another member of the multidisciplinary team that is putting together the CFI grant application. His specialty is thin films, and nanotechnology. He has just received funding for a sputtering system, which will allow us to try out some of our new ideas with antennas and stripline devices.

FUNDING

The iCORE funding of $200,000 per year is leveraged by $120,000 per year from the TRLabs chair program and $120,000 per year from NSERC. The University of Calgary contributes $164,000 to the chair program.

New Funds Acquired as Prime Investigator
Funding secured this year includes $39,348 from an NSERC Equipment Grant for a Laser Cutting Facility for the RF Wafer Prober, an NSERC Discovery Grant for $37,320, $67,700 from the Canadian Microelectronics Corporation (CMC) for the IC design Server and Workstations, $100,00 for Integrated Circuit Fabrication Grants from CMC, and $40,000 in Microwave Office Software donation from Applied Wave Research in the US.

New Funds Acquired as Co-Investigator
These funds include $55,000 from Micronet (Graham Jullien, PI, $225,000 total), and $300,000 from the CCIT Intelligent Technologies budget to construct an RF Shielded Room and a Clean Room Facility (Graham Jullien and Dr Haslett).

INTELLECTUAL PROPERTY

Patent Activity this year:

1. M. L.Holbert, J.W. Haslett, R.E. Smallwood and F.N. Trofimenkoff, Subsurface Signal Transmitting Apparatus, US Patent # 6,405,795, Issued June 18th, 2002, Canadian Patent #2151525 issued December 31, 2002.

2. J.W. Haslett, B. A. Georgescu, H. Pekau and J. McRory, Monolithic Transformer Compensated Circuit, full US and Canadian Patents filed January 2003.

3. C. D. Holdenried, J.W. Haslett, J.G. McRory, and R.J. Davies, Branch Logarithmic Amplifier and Logarithmic Amplifier Delay Circuitry, US and Canadian Patents Filed, US file # 10/156,731, April 2002.

PUBLICATIONS

Refereed Journal Publications

1. A. Garg, G.A Jullien, G. McGibney, and J.W. Haslett, "A Modulus Replication Adaptive Filter IP Core," *Canadian Journal of Electrical and Computer Engineering*, vol.27, no. 4, October 2002, pp. 177-181.
2. C.D. Holdenried, J.W. Haslett, J.G. McRory, R.D. Beards, and A.J. Bergsma, "A DC-4 GHz True Logarithmic Amplifier: Theory and Implementation," IEEE *Journal of Solid-State Circuits*, vol. 37, no. 10, October 2002, pp.1290-1299.

Conference Papers

1. C. D. Holdenried and J.W. Haslett, "Two Baseband Logarithmic Amplifiers Using Parallel Feedback Amplifier Cells," Proc. of Wireless 2002, Calgary, Alberta, July 2002, pp. 181-189.
2. B. A. Georgescu, J.W. Haslett, and J. McRory, " Practical Synthesis of Optimized Inductor Circuits," Proc. of Wireless 2002, Calgary, Alberta, July 2002, pp. 206-209.
3. M. Lynch and J.W. Haslett, "The Design of a 17.35 GHz LNA and Mixer," Proc. of Wireless 2002, Calgary, Alberta, July 2002, pp. 505-514.
4. M. Lynch, J.W. Haslett, G. McGibney, and A. Garg, "A Novel Gigabit Radio Transceiver for System-on-Chip Wireless LAN," Paper and Poster Presentation, International Workshop on System-on-Chip, Banff, Alberta, July 2002, pp. 420-429.
5. A. Garg, G.A.Jullien, G. McGibney, and J.W. Haslett, "A Modulus Replication Complex Adaptive Filter IP Core," Paper and Poster Presentation, International Workshop on System-on-Chip, Banff, Alberta, July 2002, pp. 430-437.
6. C. D. Holdenried and J.W. Haslett, "Two Baseband Logarithmic Amplifiers Using Parallel Feedback Amplifier Cells," Poster Presentation, Canadian Microelectronics Corporation Texpo 2002, Ottawa, Ontario, June 18, 2002. This poster won the CMC Componentware/CAD Award, one of three national awards presented at the workshop.
7. M.W. Lynch, C. Holdenried, and J.W. Haslett, "A 17-GHz Direct Down-Conversion Mixer in a 47-GHz SiGe BiCMOS Process," accepted for presentation at the Radio Frequency Integrated Circuits Symposium, Philadelphia PA, June 2003, pp. 461-464.
8. A. Garg, I. Steiner, G.A. Jullien, J.W. Haslett, and G.H. McGibney, "A High Speed Complex Adaptive Filter for an Asymmetric Wireless LAN Using a New Quantized Polynomial Representation," accepted for presentation at the IEEE International Circuits and Systems Conference, (ISCAS), Bangkok, Thailand, May 2003.