

Joe S. Kelly

ON THE SHOULDERS OF
GIANTS

ELECTRICAL ENGINEERING THE DWIGHT **LOOK** **TEXAS A&M UNIVERSITY**
COLLEGE OF
ENGINEERING

R E S E A R C H R E P O R T 2 0 0 1

Introduction

Dear Colleagues and Friends:

This report presents a summary of research done by the faculty and students of the electrical engineering department at Texas A&M University over a period of two years, 1997-1999. We intend to bring out this report every two years in the future. There are eight broad focus areas of research, although several faculty members have research interests spanning over multiple areas. The report is organized to give a brief overview of each area. The publications and research grants are, however, listed for each faculty individually, as a particular faculty member may have research spanning over multiple areas.

Although the primary objective of the report is to bring to your attention the work of our faculty over the two-year period, I would also like to take this opportunity to make you aware of the quality and strength of our faculty and students, which have been on a steady rise over the last several years. For your convenience, we have organized some of the important facts about the department on the next page. As you can see, we have a very accomplished and nationally visible faculty that is contributing extensively to creating and disseminating new knowledge. As you will see on perusing the report, these faculty members are also very active in editorial, society leadership and other service positions. We also have very high quality graduate students, a vast majority coming from some of the topmost schools around the globe. These students are contributing tremendously to the growth in quality and the quantity of research in the department.

I just cannot help mentioning something that very few electrical engineering departments in the world can claim. We are fortunate to have one of our former faculty awarded the 2000 Nobel Prize in Physics. As you know, Jack Kilby received this honor in December 2000 for his part in the invention and development of the integrated circuit at Texas Instruments in 1958. He was a Distinguished Professor in the Department of Electrical Engineering at Texas A&M from 1978 to 1985. In 1995, Texas A&M conferred upon Jack an Honorary Doctor of Science degree to recognize his contributions to science and engineering at Texas A&M. In 1998, Texas Instruments endowed the TI/Jack Kilby Chair in the Department of Electrical Engineering to recognize the long-term relationship between Jack and the department. This endowment was part of a \$5.1 million gift to our department in 1998.

I would also like to take this opportunity to invite you to visit our website at <http://ee.tamu.edu>. Here you will find a detailed description of our programs, background of our faculty members, our monthly news and previous issues of our newsletter, *Currents*.

Sincerely,



Chanan Singh

**Man's mind stretched to a new idea never goes back to its original dimensions.
- Oliver Wendell Holmes**



FACT SHEET
DEPARTMENT OF ELECTRICAL ENGINEERING
TEXAS A&M UNIVERSITY

FACULTY

Faculty – Assistant, Associate and Full Professors	49
Endowed Chairs and Professorships	11
IEEE Fellows	16
Members National Academy of Engineering or Science	3
Young Investigator Awards (NSF, ARO, ONR)	11
Refereed journal publications per Faculty	2.6

GRADUATE STUDENTS

Full-time	400
Doctoral	210
Average Quantitative GRE Score of Doctoral Students	780 (Max 800)

UNDERGRADUATE STUDENTS

Electrical and Computer Engineering	1065
National Merit Scholars	33

RESEARCH AREAS

Analog and Mixed-Signal
 Biomedical Imaging and Genomic Signal Processing
 Computer Engineering
 Control Systems
 Electric Power and Power Electronics
 Electromagnetic and Microwaves
 Solid State Electronics and Electro-Optics
 Telecommunications and Signal Processing

Faculty



Chanan Singh

Professor and Dept. Head
Ph.D. Univ. of Saskatchewan, 1972
Power Systems
IEEE Fellow



Ali Abur

Professor
Ph.D. Ohio State University, 1985
Power Systems



Shankar Bhattacharyya

Professor
Ph.D. Rice University, 1971
Control Systems
IEEE Fellow



James "Bob" Biard

Professor
Ph.D. Texas A&M University, 1957
Solid State Electronics
IEEE Fellow, National Academy of
Engineering



James Blake

Associate Professor
Ph.D. Stanford University, 1988
Solid State Electronics, Fiber Optics



Karen Butler-Purry

Associate Professor
Ph.D. Howard University, 1994
Power Systems



Pierce Cantrell

Associate Professor
Associate Provost, Information
Technology
Ph.D. Georgia Inst. of Tech., 1981
Computer Communications



Andrew Chan

Professor
Ph.D. Univ. of Washington, 1971
Electromagnetics



Kai Chang

Professor
Ph.D. Univ. of Michigan, 1976
Microwave/Millimeter Wave
IEEE Fellow



Gwan Choi

Associate Professor
Ph.D. Univ. of Illinois, 1994
Computer Engineering



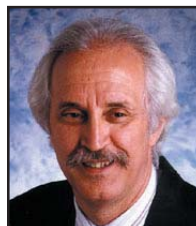
Ugur Cilingiroglu

Professor
Ph.D. Southhampton Univ., 1978
Signal Processing



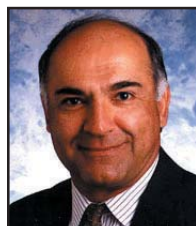
Anirudda Datta

Associate Professor
Ph.D. Univ. of Southern Cal. 1991
Control Systems



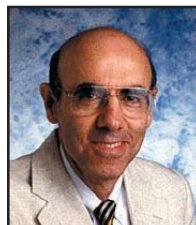
Edward Dougherty

Professor
Ph.D. Rutgers University, 1974
Biomedical Imaging



Mehrdad Ehsani

Professor
Ph.D. Univ. of Wisc.-Madison, 1981
Power Electronics/Power and Control
Systems
IEEE Fellow



Ohannes Eknoyan

Professor
Ph.D. Columbia University, 1975
Solid State/Electrooptics



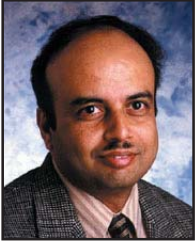
Sherif Embabi

Associate Professor
Ph.D. University of Waterloo, 1990
Microelectronics



Jo Howze

Professor
Ph.D. Rice University, 1970
Control Systems



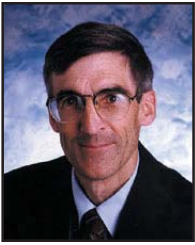
Prasad Enjeti

Professor
Ph.D. Concordia University, 1988
Power Electronics and Clean Power
IEEE Fellow



Garng Huang

Professor
Ph.D. Washington University, 1980
Power and Control Systems



John Fleming

Senior Lecturer
Ph.D. Cornell University, 1977
Control Systems



Aydin Karsilayan

Assistant Professor
Ph.D. Portland State University, 2000
Signal Processing and Adaptive
Systems



Costas Georghiades

Professor
Ph.D. Washington University, 1985
Communications
IEEE Fellow



Nasser Kehtarnavaz

Professor
Ph.D. Rice University, 1987
Image Analysis/Image Processing



Norman Griswold

Professor
Ph.D. University of Kansas, 1976
Communications/Image Processing



Mladen Kezunovic

Professor
Ph.D. University of Kansas, 1980
Power Systems
IEEE Fellow



C. Roland Haden

*Professor, Vice Chancellor and
Dean of Engineering*
Ph.D. University of Texas, 1965
Solid State Electronics
IEEE Fellow



Mi Lu

Professor
Ph.D. Rice University, 1987
Computer/Parallel Processing



Don Halverson

Associate Professor
Ph.D. University of Texas, 1979
Telecommunications and Signal
Processing



Franco Maloberti

Professor
Ph.D. University of Parma, 1968
Signal Processing
IEEE Fellow



Ray Mercer

Professor
Ph.D. University of Texas, 1980
Computer Aided Design/Synthesis
IEEE Fellow



John Painter

Professor
Ph.D. Southern Methodist University,
1972
Telecommunications and Signal
Processing, Control



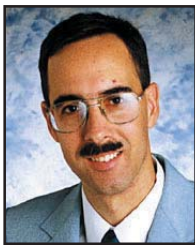
Krzysztof Michalski

Associate Professor
Ph.D. University of Kentucky, 1981
Electromagnetics
IEEE Fellow



Donald Parker

Professor
Ph.D. Texas A&M University, 1969
Solid State Electronics



Scott Miller

Associate Professor
Ph.D. University of California, San
Diego, 1988
Communication Theory and Systems



Alton D. Patton

Professor
Ph.D. Texas A&M University, 1972
Power Systems
IEEE Fellow



Patrick Morgan

Assistant Professor
Ph.D. Stanford University, 1996
Magnetic Resonance Imaging



Narasimha Reddy

Associate Professor
Ph.D. University of Illinois at Urbana-
Champaign, 1990
Computer Engineering



Krishna Narayanan

Assistant Professor
Ph.D. Georgia Institute of
Technology, 1998
Communication Theory



B. Don Russell

*Professor and Associate Dean of
Engineering*
Ph.D. University of Oklahoma, 1975
Member Natl. Academy of Engineering
Power Systems
IEEE Fellow



Robert Nevels

Professor and Asst. Dept. Head
Ph.D. University of Mississippi, 1979
Electromagnetics



Edgar Sánchez-Sinencio

Professor
Ph.D. University of Illinois, 1973
Analog Microelectronics
IEEE Fellow



Cam Nguyen

Professor
Ph.D. Central Florida, 1990
Microwave/Millimeter Wave



Erchin Serpedin

Assistant Professor
Ph.D. University of Virginia, 1999
Signal Processing



Weiping Shi

Associate Professor
Ph.D. University of Illinois at Urbana-Champaign, 1992
Computer Aided Design of VLSI



John Tyler

Senior Lecturer
M.S. American Technological University, 1979
Electric Circuits/Electromagnetics/Engineering Education



José Silva-Martinez

Associate Professor
Ph.D. Katholieke Universiteit Leuven, Belgium
Analog and Mixed Signal



Ting Chi Wang

Assistant Professor
Ph.D. University of Texas, 1993
Design Automation of VLSI Circuits, Design and Analysis of Algorithms



Fred Strieter

Adjunct Professor
Ph.D. University of California at Berkeley, 1960
Solid State



Xiadong Wang

Assistant Professor
Ph.D. Princeton University, 1998
Telecommunications and Signal Processing



Bogumila Styblinski

Senior Lecturer
Ph.D. Warsaw Technical University, 1977



Karan Watson

Professor and Associate Dean of Engineering
Ph.D. Texas Tech University, 1982
Computer Engineering
IEEE Fellow



Chin B. Su

Professor
Ph.D. Brandeis University, 1979
Optoelectronics/Fiber Optics



Mark Weichold

Professor and Associate Provost for Undergraduate Programs and Academic Services
Ph.D. Texas A&M University, 1983
Solid State Device Fabrication



Henry Taylor

Distinguished Professor
Ph.D. Rice University, 1967
Fiber Optics/Integrated Optics/Laser Diodes/Solid State
IEEE Fellow



Steve Wright

Professor
Ph.D. University of Illinois, 1984
Biomedical Imaging



Hamid Toliyat

Associate Professor
Ph.D. University of Wisconsin-Madison, 1992
Electrical Machines/Power Electronics



Zixiang Xiong

Assistant Professor
Ph.D. University of Illinois at Urbana-Champaign, 1996
Data Compression/Multimedia/Digital Communications/Image Processing

Areas of Research

Analog and Mixed-Signal

Faculty

Edgar Sánchez-Sinencio—Area Leader/Professor
Ugur Cilingiroglu—Professor
Sherif Embabi—Associate Professor

Aydin Karsilayan—Assistant Professor
Franco Maloberti—Professor
José Silva-Martínez—Associate Professor

Summary

The Analog and Mixed-Signal group at Texas A&M is involved with the design, simulation, CAD, fabrication and testing of integrated circuits and systems. Research facilities allow students and faculty to do design, simulation and measurements comparable to the industry since they have all the key simulators such as CADENCE, MATLAB and System View. Devices and circuit characterization from 0.01Hz up to 13GHz can be done in the lab facilities. The fabrication is done through MOSIS, but the rest, including printed circuit boards fabrication, is done in the research facilities.

Current research in the analog and mixed-signal systems includes low-voltage/low-power circuits, RF IC communications, built-in testing and analog to digital converters. This research is driven by the industrial needs for high density, high-speed, high frequency electronic circuits, which also have low power consumption and which are also readily manufacturable and testable.

Recent trends in research at Texas A&M also are towards wireless building blocks such as Bluetooth, Broadband and Fiber Optical Communications. A few examples of the current research are next described.

Design of OTAs and OPAMPs

The Analog and Mixed-Signal group has introduced in the past several novel concepts and circuits in the analog arena, mainly analog filters, data converters, artificial neural networks and tuning systems.

Recently this group discovered new solutions for the design of analog systems in the range of 100 MHz-1 GHz using pure CMOS technologies. Operational transconductance amplifiers with gain-bandwidth products in the range of 2 GHz and dc gain of 80 dB are achieved. These circuits open the door for switched-capacitor circuits running up to 100 M samples per second. Low distortion operational transconductance amplifiers for continuous-time filters in the range of 100-500 MHz also have been developed. Compact and very power efficient, a 150 MHz linear filter using these amplifiers consumes 1/3 of other solutions.

Wide band continuous-time variable gain amplifiers also have been developed. The use of wide band current gain amplifiers allows the increase in frequency response of the systems to the range of 500 MHz with a DC gain of 40 dB, gain-bandwidth product of 50 MHz in 0.35 μm process. Compensating techniques for the further extension of the bandwidth up to 1 GHz also are being developed at Texas A&M.

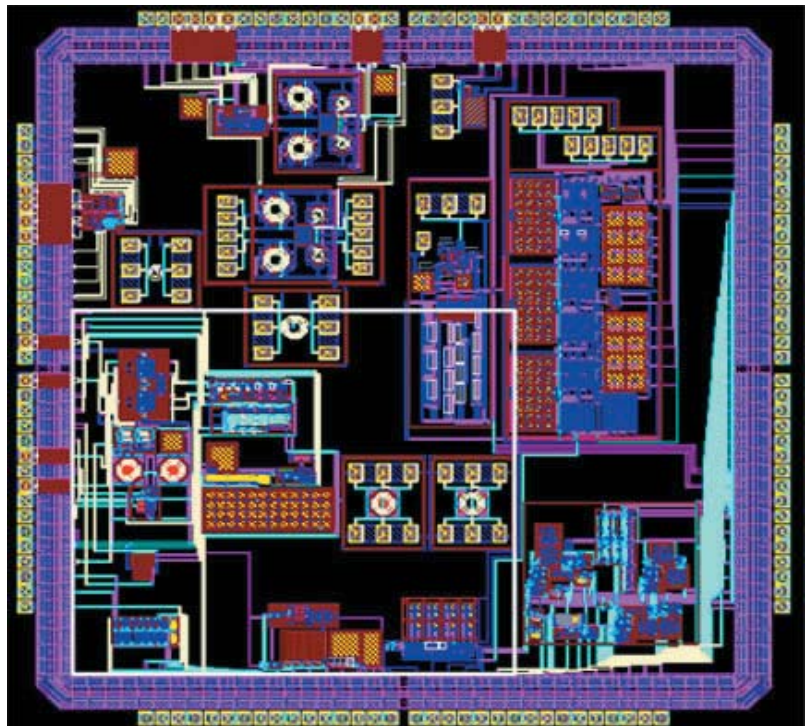
On-Chip Spectrum Analyzer

Recently, a built-in testing and characterization methodology for analog and mixed-signal circuits was proposed. The input and output signals of the built-in circuitry are digital. The main purpose of this system is to reduce the testing cost by including within the IC the signal generators and interpretation circuits to ideally avoid the need of conventional testing. Realistically, the testing time of the IC should be reduced, thus economical and relatively simple built-in circuits need to be developed.

The overhead for built-in testing circuits is easily compensated by the reduction of testing time using conventional industry equipment. For the linear circuit characterization the transfer function is obtained, including the magnitude and phase by using a down conversion scheme such that the information of magnitude and phase are given by DC and low frequency values. The non-linear characterization is obtained by using a programmable high-Q band-pass filter that is synchronized with the stimuli generator. To achieve this, switched-capacitor techniques are used.

Bluetooth Receiver

Bluetooth (below) is a new technology for small-form factor, low-cost, short-range radio links between mobile PCs, mobile phones and other portable devices. It is believed



Analog and Mixed-Signal contd.

to be the fastest growing industry standard ever. Bluetooth technology is intended to replace all cables and connecting devices. Some of the areas of applications include: biomedical monitoring, wireless computer interconnections, wireless sensor networking, automotive and internet bridge.

The objective of the project is to design, lay out and characterize the performance of a fully integrated Bluetooth receiver. Two main design stages are being carried out: system design and circuit design. In the system design stage, the specifications for a low-IF receiver architecture are determined.

In the design stage, the system is partitioned in several blocks and the design of each of them is carried out. The system and circuit designs are not independent, since realistic specifications must be set to each block and it calls for an iterative design. One of the main driving forces in the design is to minimize the power consumption and to demonstrate that the CMOS process can be used to design high-performance RF integrated circuits.

The receiver can be partitioned into two main components: The RF stage, which takes the incoming signal from the antenna, amplifies and downconverts it to the IF frequency, and the baseband stage, which filters, amplifies and demodulates the downconverted signal.

The challenges and design considerations for each stage are different since the characteristics of the signals involved are quite different. In the RF stage, the signals are very small and the frequency is very high (2.4 - 2.5 GHz) imposing very stringent specifications in the noise figure of the blocks and on the linearity.

On the other hand, the baseband processing involves precise filtering, image rejection and demodulation of the signal with low degradation of the signal to avoid altering the information

contained in it. The work team for this project involves eight graduate students and one professor.

The technology used for the implementation of the receiver is the 0.35 μ m CMOS process of TSMC. The design of the receiver is the result of a team effort, thus the benefits of the experience obtained during the design and testing of the circuit will be shared among a large group of students.

On-Chip Automatic Tuning, DSL Circuits and Optical Communication Circuits

The purpose of on-chip automatic tuning is calibration of continuous time circuit blocks to assure given specifications. Although the concept can be applied to many circuits in general, the target is automatic tuning of high-frequency filters ($f > 1$ GHz) with high quality factors ($Q > 50$). An efficient solution will enable integration of external high-Q filters in wireless transceivers, leading to single chip solutions.

Several novel techniques with successful implementations were reported in this area. However, none of the existing techniques have gained commercial acceptance due to very stringent filter specifications. The most current study is focused on robust techniques that are manufacturable in a standard digital CMOS process. A fully digital CMOS tuning circuitry is being developed such that the performance will be insensitive to process variations.

Research on DSL line drivers is getting more attention due to its market potential. A solution for low cost, low distortion and highly linear adaptive line drivers is also being investigated in this field.

Another research area is front-end circuits for optical communications. Main topics include the design of transimpedance amplifiers, clock and data recovery circuits, drivers and several analog circuit blocks. For high-end applications (> 10 GB/s), SiGe and GaAs, technologies can be utilized whereas deep-submicron CMOS can be preferred for its low cost at lower bit rates.



Biomedical Imaging and Genomic Signal Processing

Faculty

Steve Wright—Area Leader/Professor

Andrew Chan—Professor

Edward Dougherty—Professor

Norman Griswold—Professor

Nasser Kehtarnavez—Professor

Patrick Morgan—Assistant Professor

Chin Su—Professor

Summary

Biomedical Imaging is a newly established, interdisciplinary specialty area in the Department of Electrical Engineering at Texas A&M University. Imaging is becoming an increasingly important tool for understanding the human system, and is used in applications from decoding the function of the genome to mapping the function of the brain. Researchers in the Biomedical Imaging group specialize in a wide variety of imaging applications involving image processing and analysis and development of new instrumentation and techniques for biomedical imaging.

Close collaborations have been established with researchers at the MD Anderson Cancer Center. The Texas A&M Biomedical Imaging Science and Engineering Center, an interdisciplinary effort involving the electrical, chemical and biomedical engineering departments, has been established on the campus of the Houston Medical Center to facilitate translating engineering research into clinical applications.

Emphasis areas in the Biomedical Imaging group are in magnetic resonance imaging, biomedical image analysis and optical imaging. Training programs have been established in MRI and image analysis for the human genome project with support from the National Institutes of Health and the National Science Foundation.

Human Genome Project Has TAMU Electrical Engineering Tie

Dr. Ed Dougherty, professor in the Department of Electrical Engineering at Texas A&M University, is currently working on a project in the area of biomedical imaging considered to be of great importance—The Human Genome Project.

Dougherty measures gene activity with engineering techniques such as signal processing, pattern recognition and image analysis. His research is supported by the National Institutes of Health (NIH), the U.S. sponsor of the Human Genome Project.

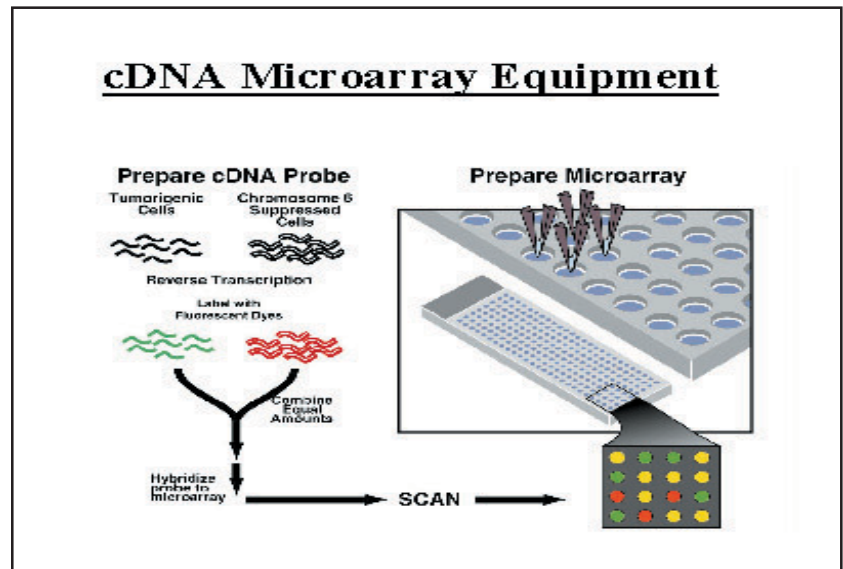
So far, tens of thousands of genes—pieces of DNA that are the basic units of heredity—already have been identified from the human genome sequence.

“The next step is studying how the genes work in conjunction with each other,” said Dougherty, who directs the Computer Aided Medical Diagnostic Imaging Laboratory in the Department of Electrical Engineering.

With these results, scientists could find out how normal cells become cancerous or how invading viruses change a cell’s genes.

Dougherty examines gene activity using microarray technology (below), a process developed a few years ago that allows for large numbers of genes to be studied together.

The method involves a robot that precisely applies tiny droplets of DNA from thousands of known genes to a small slide. RNAs obtained from tissue samples and tagged with fluorescent dyes are placed on the slide and bond with appropriate genes. (RNA carries genetic information stored by DNA to other parts of a cell.)



The slides are put into a scanning microscope to form images. These images are digitized, and the brightness of each fluorescent spot is measured by image processing software (above).

Dougherty and research assistant Seungchan Kim analyze the digitized microarray images gene by gene, measuring the color and intensity of the fluorescence. They use an image processing technique Dougherty developed with researchers at the NIH National Human Genome Research Institute (NHGRI). The information indicates which genes have been expressed, or turned on.

The technique already has played a role in one of the first large-scale studies on cancer genetics made possible by the findings of the Human Genome Project. Dougherty was part of a team of scientists from 11 laboratories in the United States, Australia and Israel in an NHGRI-led study that discovered genetic differences for melanoma cancer subgroups. The research was reported in the August 3, 2000 issue of *Nature*.

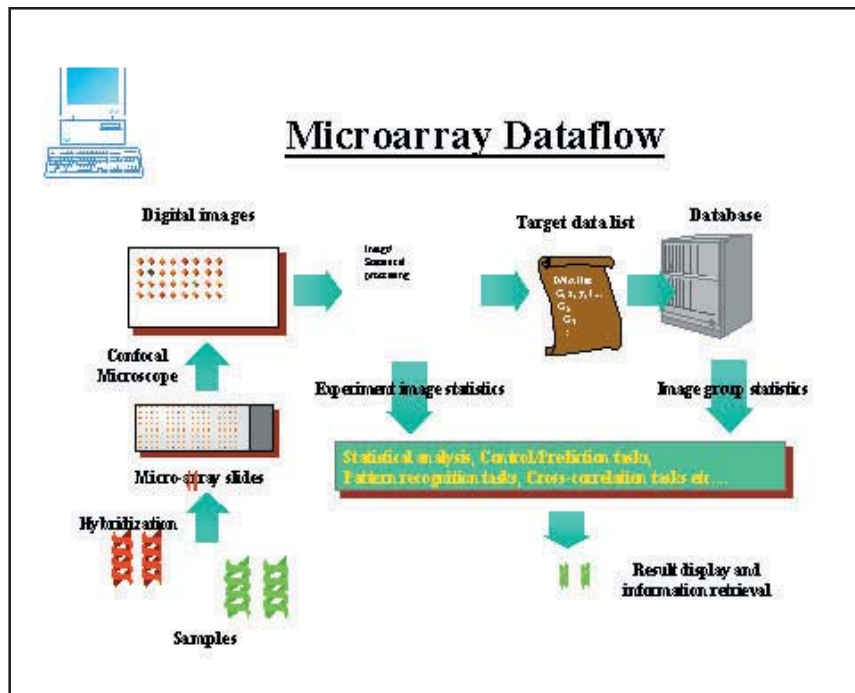
Classifying cancer on a molecular level may lead to therapies tailored to individual patients, say researchers with the genome project.

“In a few years, you’re going to see numerous algorithms being developed to classify types of diseases,” Dougherty added.

Research will involve engineers, computer scientists, mathematicians and statisticians, as well as biologists, chemists and physicians working on big teams. Dougherty compares the effort to the early days of the space program.

“This is probably the most exciting scientific project on the face of the earth since the moon shot.”

Contributed by TEES Communication



Computer Engineering

Faculty

Ray Mercer—Area Leader/Professor
 Pierce Cantrell—Associate Professor
 Gwan Choi—Associate Professor
 Mi Lu—Professor

A.L. Narasimha Reddy—Associate Professor
 Weiping Shi—Associate Professor
 T.C. Wang—Assistant Professor
 Karan Watson—Professor

Summary

The Computer Engineering Group within the Department of Electrical Engineering at Texas A&M offers programs of study leading toward six different degrees. These are: BS, MS and Ph.D. in electrical engineering and BS, MS and Ph.D. in computer engineering. The Computer Engineering programs for both graduates and undergraduates are administered and taught by a joint committee of faculty members from the computer science and electrical engineering departments.

Flexible programs of study are available for each degree and laboratories for undergraduate courses are regularly updated and revised to keep track with significant industrial developments in these fields of study.

Research in the Computer Engineering Group within the Department of Electrical Engineering extends across a spectrum that includes: synthesis and analysis techniques for Integrated Circuits; logic level design verification, analysis and testing, computer architecture; system fault-tolerance; and high-speed computer networks with associated protocols and their performance criteria.

Faculty members in the Computer Engineering group come from the finest educational and industrial organizations. Their research programs are nationally recognized and well funded. Many of the faculty members have won numerous national awards, such as those given by the National Science Foundation (NSF), and international awards, such as Best Paper Awards at highly competitive international technical conferences.

New Parasitic Extraction Algorithms and Their Applications

To make computers run faster, the semiconductor industry is aggressively reducing the feature size and increasing the frequency of Very Large Scale Integration (VLSI) circuits. This is because the smaller the transistors and the thinner the interconnect wires, the less time it takes to charge and discharge the gates and wires, and the faster the transistors switch.

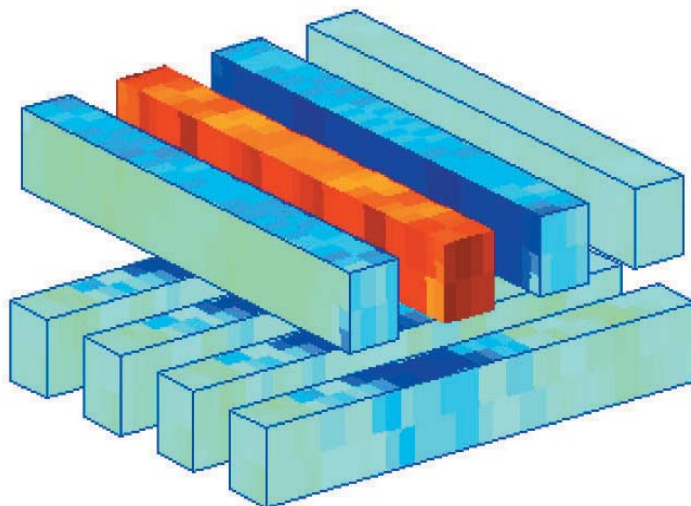
For example, from Pentium 3 to Pentium 4, Intel reduced the feature size from 0.25 μ m to 0.18 μ m, and increased the clock frequency from hundreds of MHz to more than one GHz.

However, as the feature size decreases, a new challenge emerges. The traditional delay model is no longer valid for deep sub-micron VLSI circuits. In the traditional model, gate delay dominates, but in the deep sub-micron model, interconnect delay dominates.

Since the interconnect delay is caused by parasitic resistance (R), capacitance (C) and inductance (L), parasitic RCL extraction for VLSI circuits that contain hundreds of millions of interconnect wires, is a top concern for delay estimation of deep sub-micron VLSI. The challenge is how to quickly and accurately extract parasitic RCL from any given circuit.

In 1998, Dr. Weiping Shi and his colleagues developed a new algorithm that can extract parasitic capacitance 100 times faster than the current best software. Therefore, the new algorithm will allow computer chip manufacturers such as IBM and Intel to design and simulate new computer chips in much less time than they do with current software.

Figure 1 (below) illustrates the charge distribution computed by the new algorithm for one particular configuration of conductors in an integrated circuit.



The main idea of the new algorithm is an adaptive refinement scheme and a fast multipole data structure for solving integral equations associated with the capacitance extraction problem. Their capacitance extraction paper won a “Best Paper” award at the Design Automation Conference, the most prestigious conference in electronic circuit design and semiconductor technology. Each year the conference receives about four hundred paper submissions and is attended by approximately fifteen thousand researchers and engineers around the world.

In the fall of 2000, Dr. Shi joined the Computer Engineering Group at Texas A&M University after his sabbatical with industry. Together with Dr. Hank Walker of the Computer Science Department, he started two research projects on testing of deep sub-micron VLSI under spot defect as well as parasitic and manufacturing variation.

The projects received two research grants from the National Science Foundation (NSF) and the Semiconductor Research Corporation (SRC). SRC is a funding agency supported by such member companies as AMD, HP, IBM, Intel, Motorola and TI, and focuses on the most important topics faced by industry.

Along with Dr. Vivek Sarin of the Computer Science Department, Shi also started a research project on fast algorithms

for inductance extraction. Inductance extraction in general is more time consuming than capacitance extraction. As the clock frequency reaches several GHz, inductance starts to play an increasingly important role in signal delay and noise. The project received another research grant from NSF, which

brought the research grant total to more than \$1 million in less than a year.

Drs. Shi, Walker and Sarin are actively working on these projects and would like to see more students participate with them, and see their results used by more people in the industry.



Control Systems

Faculty

Shankar Bhattacharyya—Area Leader/Professor

Jo Howze—Professor

Anirudda Datta—Associate Professor

Garng Huang—Professor

John Painter—Professor

John Fleming—Senior Lecturer

Summary

The Control Systems group in the Department of Electrical Engineering at Texas A&M University has research interests concentrated on the fundamental aspects of Adaptive Control, Robust Control, Linear Multivariable Systems, Computer Aided design, Optimization, Nonlinear Control Systems, Control of Power Systems, Parallel Computation, Intelligent Control and Biological Control Systems.

Bhattacharyya's research is supported by the National Science Foundation (NSF) and the Texas Advanced Research Program, and concentrates on developing new and effective approaches to Robust Control. Datta's research on Adaptive and Robust Control also is supported by the NSF and the Texas Advanced Research Program. They include Biological Control Systems and control aspects of genomics.

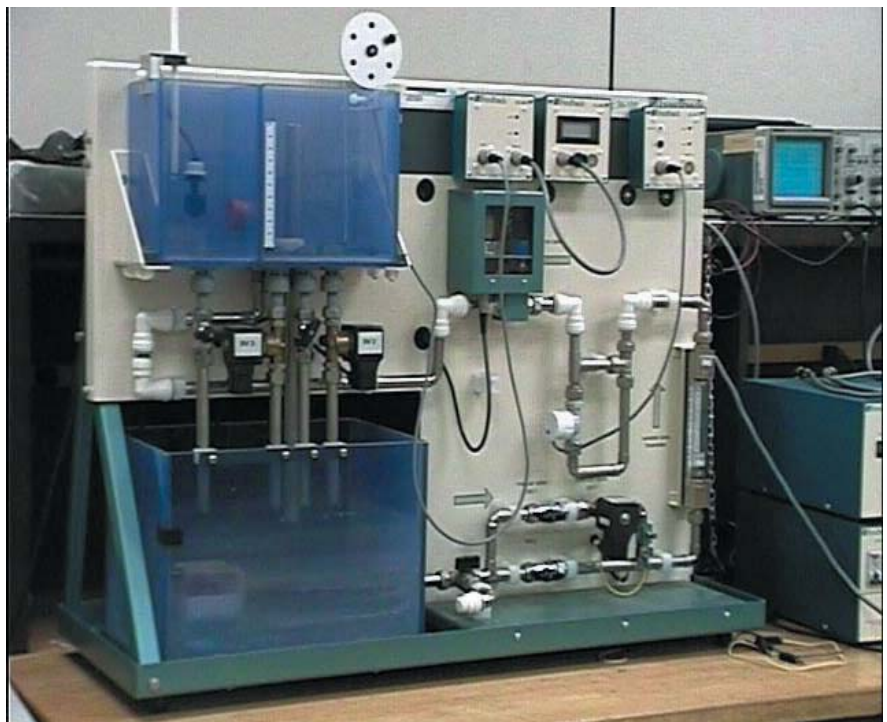
Howze, who holds the Ford Design Chair Professorship, has ongoing research, supported by the 3M Corporation, on applying control theory to improve manufacturing processes. Huang has ongoing research, supported by NSF, on the stability of nonlinear control systems and parallel computation with applications to the control of power systems.

Fundamental and Applied Research on PID Controllers

The Proportional Integral Derivative (PID) controller is universally used in the control engineering field and is the single most important element in a control system. PID controllers are the workhorses of control systems and can be found in aerospace systems, motion control systems, process control and manufacturing. They can be implemented as electrical, mechanical, hydraulic and pneumatic systems. Indeed, 95-98 percent of the control systems in the world use PID controllers.

The Control group recently has achieved an important breakthrough in the theory and design of PID controllers. This breakthrough was obtained by Drs. A. Datta, S.P. Bhattacharyya and their graduate students, M.T. Ho and G. de Silva. This research, which is supported by the National Science Foundation (NSF) and the Texas Advanced Research Program, has opened up the possibility of improved and optimal designs of PID controllers (right). The research has been reported in conference and journal papers and a Springer-Verlag monograph in *Advances in Industrial Control*.

At present, a software package incorporating the new technique is under preparation. The group is planning to cooperate with some industries to tailor their results and the software to address the needs of the different industries. Given the wide application of PID controllers, these results can potentially yield very significant improvements in efficiency



in industrial control, yielding greater productivity and substantial savings.

Additional fundamental research in the area of control system architectures is under the direction of Dr. Jo W. Howze. It has been shown that different control system architectures can produce the same input-output performance, but result in vastly different robustness, control effort, noise and disturbance

Control Systems contd.

rejection properties. This research endeavors to understand and capture this flexibility for improved overall performance. In addition, Howze is applying automatic feedback control and sensitivity theory in the area of design engineering with the objective of developing a computer aided tool that can aid in the critical parameter identification step that is crucial in the design process.

Howze also is heavily involved in applications of controls, primarily in the areas of crystal growth processes and fiber optical technology. The crystal growth research centers around improved models of the Czochralski crystal growth process, which captures essential aspects, yet is control systems relevant. Also, his work in fiber optics involves innovative actuators and control algorithms for tunable Fiber Bragg Gratings.



Electromagnetics and Microwaves

Faculty

Kai Chang—Area Leader/Professor

Andrew Chan—Professor

Krzysztof A. Michalski—Associate Professor

Robert Nevels—Professor

Cam Nguyen—Professor

Steve Wright—Professor

Summary

Research activities in the Electromagnetic and Microwave area cover a broad spectrum of applications, from space to wireless communications. In particular, research focuses on both the theoretical and experimental aspects of antennas; electromagnetic theory; electromagnetic wave scattering; active and passive microwave and millimeter wave circuits; microwave wireless communications and systems; wavelet technology; surface sensors and ground penetration radar; phased array antennas; and microstrip antennas.

Significant research progress has been made in active antennas and power combining microwave integrated circuits and antennas, microwave power transmission, ground penetration radar, magnetic resonance imaging, Green's function and numerical methods and wavelet techniques.

Novel Low-Cost Antenna Beam Steering Techniques

Researchers in the Electromagnetics and Microwave group at Texas A&M University have developed a new low-cost antenna beam steering technique, electronically steerable antenna arrays (below). These arrays have many applications in wireless communications, satellite communications, radar and sensor systems.

The conventional phased array antenna system used for fast beam steering is complex, expensive, lossy and bulky. Consequently, the use of phased arrays is limited to a few sophisticated expensive military and space systems. To overcome these problems, Texas A&M researchers have developed a low-cost antenna beam steering technique using electromagnetically perturbed transmission lines (U.S. patent pending).

The new technique uses multi-transmission lines perturbed by the proximity of a movable dielectric perturber. The very small movement can be accomplished by a piezoelectric transducer or a MEMS (microelectro-mechanical system) device. The perturbation introduces a progressive phase shift between the neighboring lines, which can be used to steer the radiation beam. Compared with a conventional phased array for beam steering, the new method does not require semiconductor or ferrite phase shifters and their associated beam forming circuits. The new technique has the advantages of low cost, simplicity, broadband, low loss, high power handling capability and low power consumption.

This research is sponsored in part by the National Science Foundation (NSF), the United States Air Force and the NASA Glenn Research Center. Other low-cost beam steering techniques, using a dielectric image-line-fed microstrip antenna array controlled by a reflector and a dielectric image-line-fed movable grating film, also have been developed in the EM group.



Electric Power and Power Electronics

Faculty

Mladen Kezunovic—Area Leader/Professor
 Ali Abur—Professor
 Karen Butler-Purry—Associate Professor
 Mehrdad Ehsani—Professor
 Prasad Enjeti—Professor

Garng Huang—Professor
 Alton D. Patton—Professor
 B. Don Russell—Professor
 Chanan Singh—Professor
 Hamid Toliyat—Associate Professor

Summary

The Electric Power and Power Electronics group conducts research for the advancement of power systems and power electronics technologies. Power systems research is performed in the areas of analysis, reliability, monitoring, control and protection of power systems. Some of the faculty also have a strong interest in control systems, digital signal processing, data communications and intelligent system applications. Power electronics research is performed in the areas of motor drives, power electronic converters, utility interface issues, active filters and electric and hybrid vehicles. Some faculty members also have strong interest in power quality and diagnostics of electrical machines.

The following are some of the noteworthy accomplishments over the past two years:

- Study of protective relaying system behavior during cascading network events.
- Development of relay testing methodology for evaluation of relay applications.
- Application of intelligent techniques to control, protect and monitor power systems.
- Implementation of different fault location methods using novel techniques such as wavelets, synchronized sampling and waveform matching.
- Enhancing state estimators with a new method for designing and upgrading the measurement system, which remains robust against contingencies and loss of measurements.
- Power system automation, control and protection with emphasis on the use of real-time embedded computer systems.
- Investigation of incipient and high impedance faults on distribution systems, including detection, characterization and identification for protection, preventive maintenance and reliability assessment.
- Five-phase electric motor drives for traction and propulsion applications.
- Condition monitoring and fault diagnosis of electric machines.
- Solving utility interface problems in power electronic systems and harmonic mitigation.
- Application of advanced signal processing and intelligent techniques to predictive maintenance of distribution systems.
- Application of geographic information systems and intelligent techniques to automation of shipboard power systems.
- An important result is the development of the concept of global decomposition and subsequent algorithms of GSIDES and SEG-GSIDES methods of multi-area production costing. The GSIDES approach allows the computation of the indices by a single decomposition and thus results in a very efficient algorithm. When simulation phase is also used, this can result in some inaccuracy. This inaccuracy can be substantially reduced by the segmented global decomposition.
- A very important idea is that of state space pruning. This concept is used to remove states that are acceptable from the state space resulting in a conditional state space in which the conditional loss of load probability is very high. The simulation performed on this state space converges much faster and the indices can then be transformed to the original state space.

Power Group Researchers Designing and Developing New Techniques for Maintaining Reliability in the Electric Utility Industry

Tremendous changes have occurred in the electric utility industry throughout the United States in response to generation competition and to mobilize for the eventual move to retail competition. A contradiction will prevail in the competitive electric market as customers demand very reliable electric service at low cost. To address that contradiction, Dr. Karen L. Butler-Purry and her research group in the Electric Power and Power Electronics area have suggested an approach that exchanges preventive maintenance and labor—the current practice—with increased online monitoring and smarter devices.

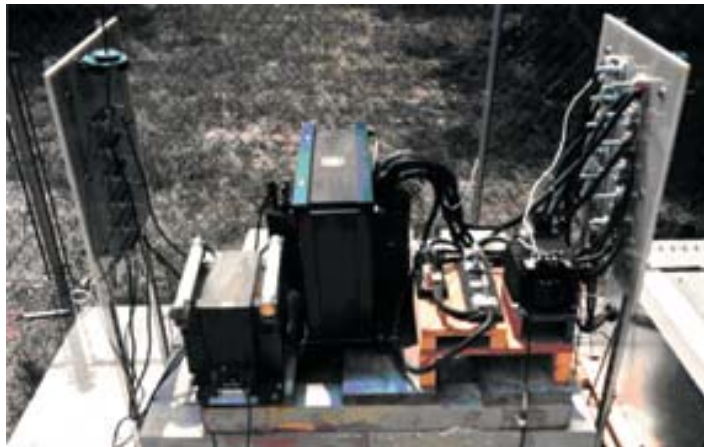
They are designing and developing new techniques for maintaining reliability through automation and intelligent identification of incipient faults to perform predictive (just-in-time)

maintenance for distribution system equipment (below) such as distribution transformers and underground cable.

Further, these techniques are being integrated into prototype software being developed by a research group led by Dr. B. Don Russell that identifies problem feeders and deteriorating

equipment to target maintenance. The software is being demonstrated on a data collection and demonstration platform that they designed and developed. The research has been funded by the National Science Foundation (NSF), TXU and the Texas Advanced Technologies Program (ATP).

Transformers and underground cable are extremely critical equipment to the reliability of distribution systems. Underground



Power Electronics contd.

cable is critical because of the wide use of underground distribution systems in suburban neighborhoods in the U.S. for aesthetics and safety and in large downtown areas and industrial sites because of the lack of space for an overhead distribution system. Transformers are extremely critical because their failure directly results in loss of service to customers.

During the past five years of the NSF project, Butler-Purry's group has been performing basic research to characterize incipient failures in distribution transformers through the monitoring of the transformer terminal parameters such as primary voltage and current and secondary voltage and current.

Field experiments were performed to generate data representing internal short circuit conditions in distribution transformers. A custom-built transformer, which included external taps strategically placed on various turns of the primary and secondary windings, was supplied at 7200 V RMS and fully loaded. Short circuit faults were staged over a period of two years until the transformer experienced a catastrophic failure.

The terminal parameters were monitored and recorded during the tests. Also, new innovative computer simulation models of short circuit and incipient internal faults were designed.

Finite element techniques were used as the basis of the models to represent the electromagnetic behavior of the individual transformer turns as a result of short circuit faults at various positions on the transformer windings. Additionally, aspects representing deteriorated insulation and arcing were included for the incipient faults.

For the TXU project, basic research was performed to characterize incipient failure in cable used in underground distribution systems. Experiments were performed on field aged and new distribution cable sections at the TAMU Downed Conductor Test Facility; leakage current was measured and recorded. Also, over a one-and-a-half-year period, cable was periodically monitored online at sites in TXU underground residential and commercial distribution systems; phase and neutral currents were monitored and recorded.

Advanced signal processing techniques were used to analyze the recorded data for the purpose of characterizing the behavior of distribution transformers and underground cable in the presence of short circuit and incipient faults. These characteristics are being utilized to develop techniques that detect the incipient failure behavior and assess the deterioration level of transformers and underground cable.



Solid State Electronics and Electro-optics

Faculty

Henry Taylor—Area Leader/Professor
James Blake—Associate Professor
Ohannes Eknoyan—Professor

Don Parker—Professor
Chin B. Su—Professor
Mark Weichold—Professor

Summary

The electro-optics program encompasses a range of technologies that make use of optical and electronic phenomena. Research areas of primary interest include fiber optics, integrated optics and semiconductor lasers. This includes exploiting the special attributes of optical fibers (high information capacity, low optical loss, small size, mechanical flexibility) and diode lasers (small size, low electrical power consumption, high-speed modulation capability) and solving problems of current technological interest. Application areas addressed in this research include communication, sensing and instrumentation.

Integrated Optics

Integrated optics is concerned with the development of thin-film components for performing functions such as modulation, switching and multiplexing of guided light beams. Much of the research is oriented towards applications in optical fiber communications, a field in which technology is evolving rapidly to keep pace with seemingly insatiable demands for bandwidth. New materials and fabrication methods for integrated optical waveguides, as well as the demonstration of new device concepts, are being explored.

A novel technique developed at Texas A&M University for making low-loss optical waveguides using the static strain optic effect has made it possible for the first time to make guided wave devices in tungsten bronze ferroelectric materials SBN and BSTN. These "super-EO materials" feature exceptionally large electro-optic coefficients, which are exploited to realize optical modulators and switches with very low electrical power consumption. The discovery that these materials have very low susceptibility to optical damage makes them attractive candidates for fabricating nonlinear frequency converters and guided-wave devices for emerging applications at visible wavelengths.

The recent emergence of wavelength-division-multiplexing in fiber optic systems has created a need for tunable filters for combining and separating the wavelength channels. At Texas A&M, a novel, tunable, add-drop filter has been produced using a phase matched strain-induced grating for polarization coupling in diffused waveguides in a lithium tantalate substrate. It is projected that extending this work to lithium niobate substrates will make it possible to meet the international standard 100 GHz spacing between adjacent wavelength channels in a polarization-independent filter with unprecedented tuning speed and tuning range.

Fiber Optic Sensors

A patented technique for making internal mirrors in optical fibers forms the basis for a new class of sensors with the fiber Fabry Perot interferometer (FFPI) as the active element. In extensive field tests, these sensors have been used to measure gas pressure in internal combustion engines, liquid pressure in pumps and strain in civil structures. The fiber optic sensors have shown an unprecedented combination of high sensitivity, ability to endure extreme temperatures and immunity from electromagnetic interference. Laboratory work is continuing on temperature and pressure transducers.

Development and Application of Novel Light Sources

New laser types are studied for application in fiber optic systems. Vertical cavity surface emitting lasers as a low-cost light source for engine pressure sensors are being investigated. An erbium-doped fiber laser also is being developed as a narrowband light source for use in an intrusion sensing system. A broadband light source is being utilized in conjunction with a fiber optic cable for remote interrogation of a compass being developed for deployment in the U. S. Navy's towed acoustic arrays.

**Integrated Optics Research in Solid State Area
Producing Devices for Future**

Manipulating guided light beams may seem like a futuristic expression found in *Star Trek* movies, but for a group of electrical engineering students the phrase is very familiar.

These students are involved in the electro-optic device research at Texas A&M University, concentrating on Integrated Optics, one of the major research projects going on in the area of Solid State Electronics.

Dr. Ohannes Eknayan, professor for the Department of Electrical Engineering, said Integrated Optics is concerned with the development of thin-film components (below) for performing functions such as modulation, switching and multiplexing of guided light beams.

The facilities at the Institute for Solid State Electronics fabricate the devices, and optical testing is done in the department's electro-optics laboratories.

construct guided wave devices in tungsten bronze ferroelectric materials SBN and BSTN. These "super-EO materials" feature exceptionally large electro-optic coefficients, which comprehend optical modulators and switches with very low electrical power consumption. Work is now continuing to produce linear and very high frequency modulators with these materials.

The recent emergence of wavelength-division-multiplexing in fiber optic systems also has created a need for tunable filters for combining and separating the wavelength channels.

In the department, an electro-optic tunable add-drop filter has been produced using a phase-matched strain-induced grating for polarization coupling in diffused waveguides in a lithium tantalate substrate.

"The electro-optic tunable filter allows one to control the flow of information containing signals that are attached to different wavelength carriers on the line, and to make certain that the signals on a specific wavelength are routed one way and those on other wavelengths go another way," Eknayan said.

These applications are aimed towards fiber-optic networks—for both digital and analog type transmission systems.

Efforts are now centered on extending this work onto lithium niobate substrates to produce components that will meet the international standards for spacing between channels with unprecedented tuning speeds.

"The demand is on high speed and wide bandwidth," Eknayan said. "Those are two areas we're addressing."

The processes used in making the devices are based on conventional semi-conductor technology, which requires photolithography and diffusion. Eknayan said the students who work on those projects help make and characterize them.

Research sponsors have included the State of Texas, the National Science Foundation, the Defense Advanced Research Project Agency, Rome Air Development Center, 3M, Lockheed Martin, Rockwell International, Input/Output Inc. and AMP Inc.

"The business of fiber optics and optical telecommunication is booming—it's a big market," Eknayan said. "The experience that students gain from their efforts here is in a big demand now."

He added that not only is there industry support but the students get to interact with the industry sponsors, giving them an advantage after graduation, and that most students graduating from the program have gone on to successful careers.

"[Former students] appreciate the work they've done in integrated optics at Texas A&M and have made substantial advancements in their chosen occupations," Eknayan said. And while this may not be as futuristic as *Star Trek*, it's a step in the right direction. "We are doing research for the next generation."



Much of Eknayan's research at the Institute is oriented toward applications in optical fiber communications, a field that is evolving rapidly to keep pace with seemingly insatiable demands for bandwidth.

"We're pursuing basically two avenues in our efforts," Eknayan said. "One is making integrated optics devices by exploiting new concepts. The other is exploring new types of electro-optic materials."

The new materials offer an advantage for making devices smaller in size than similar devices constructed with more conventional materials. They also allow more efficient electrical power consumption.

"We have to apply an electrical signal on the surface of those optical devices to control their operation," Eknayan said. "By using these new materials, the requirement for electrical power is reduced significantly."

A technique that was developed at Texas A&M creates low-loss optical waveguides using the static strain-optic effect. This method made it possible for the first time to



Telecommunications and Signal Processing

Faculty

Costas Georgiades—Area Leader/Professor
 Andrew K. Chan—Professor
 Edward Dougherty—Professor
 Norm Griswold—Professor
 Nasser Kehtarnavaz—Professor
 Garng Huang—Professor

Scott Miller—Associate Professor
 Krishna Narayanan—Assistant Professor
 Erchin Serpedin—Assistant Professor
 Xiadong Wang—Assistant Professor
 Zixiang Xiong—Assistant Professor

Summary

The Telecommunications and Signal Processing group (TSP) at Texas A&M University is a cooperative program for students and faculty interested in the theoretical development and applications of statistical communication, estimation and information theories and signal processing.

Communications research focuses on the process whereby information is conveyed from a source to a destination via a variety of media, including copper wires, coaxial cables and optical fibers, as well as a variety of wireless techniques including radio frequencies, microwaves and satellites. Techniques such as modulation/demodulation, error control coding/decoding, source compression and encryption/decryption all fall under this general area.

Digital Signal Processing (DSP) consists of techniques and algorithms for the manipulation of digital signals. Recently there has been a considerable increase in DSP applications mainly due to the availability of cost-effective and computationally efficient DSP microprocessors. Today, DSP constitutes a multi-billion dollar market spanning many areas including telecommunications, multi-media, video/graphics processing and speech/sound processing.

Research in the TSP area is coordinated through several different laboratories. These labs are funded by several government agencies as well as many prominent, industrial research partners. A brief description of the labs in the TSP area is given in the following:

Wireless Communications Laboratory

The Wireless Communications Laboratory (WCL) was created in 1996 under National Science Foundation (NSF) funding and matching funds from the College of Engineering and the Department of Electrical Engineering at Texas A&M. The purpose of the WCL is to pursue research in communications with emphasis on wireless systems, from the algorithm design to implementation.

The WCL currently consists of six faculty members and approximately 50 graduate students working on cutting edge research in various areas of wireless communications, including such topics as space-time coding and signal detection, code-division multiple-access, advanced coding techniques, equalization and channel estimation, image and video compression and processing and wireless networks. As an indication of the quality personnel in the WCL, all four of the junior faculty associated with this lab have been awarded the prestigious NSF CAREER award. More details about the WCL can be found on its web page at <http://wcl3.tamu.edu/>.

Wavelet Innovation Laboratory

The Wavelet Innovation Laboratory (WIL) is researching various novel applications of wavelet techniques in such areas as medical diagnosis, industrious detection, image segmentation and remote image processing. More details about the WIL can be found on its web page at <http://ee.tamu.edu/~wilab/>.

Multimedia Communications and Networking Laboratory

Research at the Multimedia Lab focuses on scalable compression and transmission of Internet and wireless multimedia. For scalable multimedia data compression, techniques being considered include efficient arithmetic coding of bit planes of transform coefficients and novel schemes of exploring the motion information for 3-D wavelet video coding. For scalable transmission of multimedia, optimal packetization and joint congestion and error control are being addressed.

A wide spectrum of cutting edge research is being performed by faculty, post-doctoral research assistants and both graduate and undergraduate students in the TSP group. Some of the ongoing research projects in the TSP group include:

- Syntactic/Semantic String Matching - This project involves the development of invariant curve matching schemes and their applications to the silhouettes of marine mammals for the identification of an individual in large databases of photos.
- Digital Embedded Watermarking - Watermarking is the process by which we hide an image in a document or other image in order to track and establish copyright information. This project is trying to establish some bounds on the number of bits that can be used and the tradeoff with compression capability.
- Optimized and Robust Wireless Communications - The successful evolution of the future high-speed wireless communication networks requires significant advances in adaptive signal processing algorithms. This research involves the development of a general and novel framework for designing robust and spectrally efficient channel estimation, synchronization and equalization algorithms.
- Iteratively Decodable Codes for Wireless Communications and Magnetic Recording - This project is currently investigating design and analysis of irregular turbo codes and other graph based codes such as low density parity check codes for applications in next-generation wireless communications applications and high density magnetic recording. The objective is to design low complexity coding schemes, which are well matched to the iterative (turbo) decoding algorithm.
- Monte Carlo Signal Processing for Wireless Communications - This project investigates the design methodologies of adaptive optimal receivers in wireless channels. The approach is to formulate the problems of signal reception in unknown time-varying channels as multivariate Bayesian interference problem. Monte Carlo signal processing methods are employed to develop adaptive systems for computing Bayesian estimates of the channel and data. An array of receiver design problems found in wireless communications is being treated under this framework.

- *Applications of Stereo Imagery to Differential Geometric Measures of Robustness* - This project combines stereo imaging with theoretical mathematics (viz. differential geometry) for applications within the areas of communications and signal processing.
- *Denoising and Compression of Large Remote Sensing SAR Images* - There is a need to remove multiplicative speckle noise in a large synthetic aperture radar (SAR) image before compressing and downloading to a ground station for remote sensing studies. This project uses the wavelet frame/SOT structure coupling with anisotropic diffusion/Markov Random Fields to efficiently accomplish this goal. The algorithm can be carried out with a fast DSP engine at near real time speed in a satellite in space.
- *Modulation and Coding Techniques for Space-Time Systems* - A promising technique to increase spectral efficiency as well as improve performance in a wireless communication system is the use of multiple transmitter/receiver antennae. This project considers the design and analysis of improved modulation and coding techniques for these so-called space-time systems. Starting from fundamental principles of communication theory, new design criteria are being developed which result in improved system design.
- *3-D Embedded Subband Coding with Optimized Truncation (3-D ESCOT)* - This project develops an efficient video coding algorithm: 3-D embedded subband coding with optimized truncation (3-D ESCOT), in which coefficients in different subbands are independently coded using fractional bit-plane coding and candidate truncation points are formed at the end of each fractional bit-plane. A rate-distortion optimized truncation scheme is used to multiplex all subband bitstreams together into a layered one. A novel motion threading technique also is used to form threads along the motion trajectories in a scene. For efficient coding of motion threads, memory-constrained temporal wavelet transforms are applied along entire motion threads. Block-based motion threading is currently implemented in conjunction with 3-D ESCOT in a real video coder. Extension of 3-D ESCOT to object-based coding also is addressed. Experiments demonstrate that 3-D ESCOT outperforms MPEG-4 for most test sequences at the same bit rate.
- *Analysis and Modeling of Gene Expression Data from cDNA Microarrays* - Microarrays provide simultaneous measurement of the expression levels of thousands of genes. Expression levels are measured by an image processing algorithm applied to a digital image of the microarray. The measurements are used to construct classifiers to discriminate among cancers (and other disease types) at the molecular level. They also are used to build models of genomic networks that characterize the communication system within the genome.

The Telecommunication's Wireless Communications Laboratory Gaining National Attention

Within the last three years, the Wireless Communications Laboratory (right) has substantially increased its national and international visibility through the hiring of five faculty.

Of the five new faculty, Dr. Scott Miller joined the department and the lab as an associate professor, having established a strong record at the University of Florida. Miller's addition to the lab added needed expertise in a number of areas, including spread-spectrum communications, code-division multiple access, synchronization and optical communications.

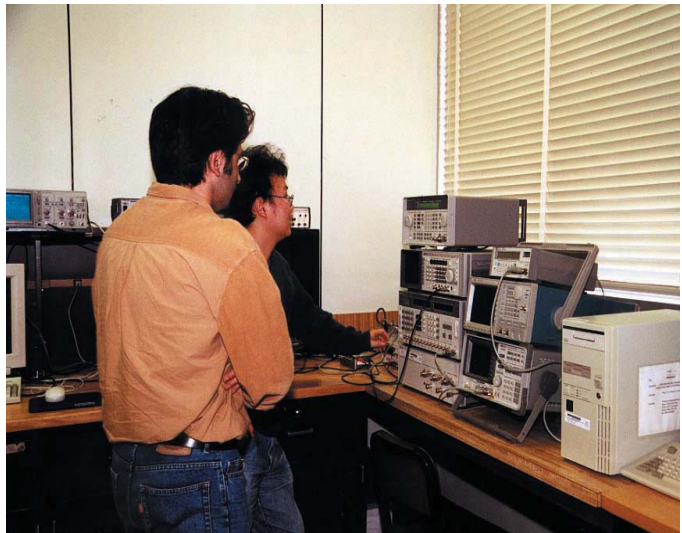
Four other additions at the assistant professor level made it possible for the group to cover all-important areas of research in physical layer telecommunications and, specifically, wireless communications.

In particular, Dr. Xiaodong Wang joined the department in June 1998 having just received his Ph.D. from Princeton. Wang's main expertise is in interference rejection techniques and multiuser detection for both uncoded and turbo coded systems, Monte-Carlo techniques for communication system design and parallel and distributed computing.

Dr. Krishna Narayanan joined the group in January 1999, having just graduated from Georgia Tech. Narayanan's expertise is in channel coding and, in particular, turbo/iterative decoding techniques.

In August 1999 the group was augmented by the addition of Drs. Zixiang Xiong and Erchin Serpedin. Xiong received his Ph.D. from the University of Illinois in 1996 and joined A&M after having spent some time at the University of Hawaii. His area of research is multimedia communication and, specifically, video, audio and image coding. Serpedin received his Ph.D. from the University of Virginia and joined the department soon thereafter. His area of research is array processing and equalization and synchronization techniques.

As an indication of the quality of the young faculty in the group, all four newly hired assistant professors have received the prestigious NSF CAREER Award since joining the department. In addition to the CAREER awards, they have been successful in obtaining other government and industry funding. Additionally and despite their short career, these young faculty members already have been appointed to serve as associate editors in the most prestigious IEEE journals in our area, with at least seven editorial positions amongst them.



Faculty in the lab also have been active in conference organization. Over the last two years, WCL faculty have helped organize the 1999 IEEE Vehicular Technology Conference, one of the most well-known conferences internationally on wireless technology, the 2001 IEEE Communication Theory Workshop and the 2001 Communication Theory Symposium, to name a few.

The quality of this program has made it possible for the lab to recruit top students from top universities around the world. The lab has approximately 70 graduate students, most of them at the doctoral level. Together with the faculty in the lab, these students work on a large variety of problems of great current interest and fundamental to telecommunications.

In recent years the WCL has been supported by a number of NSF and other government grants, as well by industry members including: The Texas Telecommunications Engineering Consortium (TxTEC); Motorola; Texas Instruments; Nortel Networks; Rockwell; and Seagate.

For more information, please visit the WCL web page at <http://ee-wcl.tamu.edu/>.

Honors & Awards

Bhattacharyya, S.

Texas Engineering Experiment Station (TEES) Fellow, 1999.
Boeing-Welliver Faculty Fellowship, 1998.

Butler-Purry, K.

TEES Select Young Faculty, 1999.
Texas A&M University Montague Center for Teaching Excellence Scholar, Center for Teaching Excellence, Sept. 1998.
Distinguished Ph.D. Alumni Award, Howard University, Washington, D.C., Nov. 1998.
Office of Naval Research Young Investigator Award, February 1999.
Texas A&M University IEEE/HKN 1998-99 Outstanding Professor in Electrical Engineering, IEEE/HKN, May 1999.
Included in the Black Achievers in Science Exhibit at the Museum of Science and Industry, Chicago, Summer 1999.

Cantrell, P.

Appointed Associate Provost for Information Technology, 1999.

Chan, A. K.

"Best Reviewer of the Year, 1999," Editorial Review Board of IEEE Transactions on Geoscience and Remote Sensing.

Datta, A.

Senior Member of IEEE, 1998.

Ehsani M.

Listed in "The Dictionary of International Biography," Cambridge, England, 27th Edition, 1999.
Listed in "Who's Who in America," 49th - current editions.
Listed in "American Men and Women of Science, 1999."
Listed in "Who's Who in the South and Southwest, 1999."

Enjeti, P.

IEEE Fellow, 1999.
2nd place winner of IEEE Industry Application Society Industrial Drives Committee (IDC) Prize Paper for the paper entitled, "A New Modular Motor-Modular Inverter (MM-MI) Concept for Medium Voltage Adjustable Drive Systems," 1999.
IEEE Industry Application Society Industrial Power Converter Committee (IPCC) Prize Paper Award, for the paper entitled: "A New Medium Voltage PWM Inverter Topology for Adjustable Speed Drives," 1999.

Georghiades, C.

IEEE Fellow, 1998.

Halverson, D.

Outstanding Professor in Electrical Engineering, Texas A&M University Department of Electrical Engineering and the Eta Kappa Nu Association, Apr. 22, 1999.

Howze, J.

Distinguished Teaching Award from The Association of Former Students, 1999.

Kezunovic, M.

IEEE Fellow, 1998.
E.D. Brockett Professorship from TEES, 1999.
CIGRE, U.S., Committee Paper Recognition Award, CIGRE General Session, 1998.
TEES Senior Fellow, 1998.

Maloberti, F.

Inaugural holder of TI/Jack Kilby Chair.

Mercer, M. R.

Texas Tech Electrical Engineering Academy Inductee, Apr. 1999.
Listed in Who's Who in American Finance and Industry, 31st Edition, 1999.
Best Paper Award, VLSI Test Conference, Dana Point, CA, 1999.

Michalski, K.,

IEEE Fellow, 1998.

Nevels, R.D.,

IEEE Region 5 Outstanding Educator Award for 1997, April 1998.

Reddy, A.L.N

Ruth and William Neely '52/Dow Chemical Faculty Fellow, 1999-2000.
IEEE Senior Member, 1998.
NSF CAREER Award, 1996-2000.

Russell, B.D.

Elected president of the Power Engineering Society of IEEE.
Diplomate of the American Board of Forensic Examiners.
Elected to the National Academy of Engineering, 1999.
Member of the Technical Activities Board and Management Committee of IEEE, 1998.
Distinguished Achievement Award from the Association of Former Students, 1998.

Sánchez-Sinencio, E.

Golden Jubilee Medal from IEEE's CASS, 1999.
Appointed TI Chair in Analog Engineering and director of Analog and Mixed-Signal Center, 1999.

Singh, C.

1998 Outstanding Power Engineering Educator Award from the Power Engineering Society of IEEE.

Toliyat, H.

TEES Select Young Faculty, 1999 .
Listed in Marquis "Who's Who in Science and Engineering," and in the 2000 "Outstanding Scientists of the 20th Century."
Space Act Award by NASA Inventions and Contributions Board, Apr. 1999.

Wang, X.

NSF CAREER Award, 1999.

Watson, K.

IEEE Fellow, 1999.
Minorities in Engineering Award from the American Society for Engineering Education, 1998.
Presidential Award for Excellence in Science, Mathematics and Engineering from the National Science Foundation, (NSF) 1998.

Wright, S.,

James Stone Faculty Fellow, Texas A&M University College of Engineering Award, Spring 1999.
TEES Fellow, 1999.

Xiong, Z.

NSF CAREER Award, 1999.
University of Hawaii Research and Training Revolving Fund Award, 1998.

Research and Publications

Important measures of professional involvement by The Department of Electrical Engineering at Texas A&M University are the quality and number of published journal articles, conference proceedings, research activities and papers written by faculty members.

The following is a list of these contributions by faculty in alphabetical order, followed by their respective areas of expertise. The areas are: Analog and Mixed-Signal=AS, Biomedical Imaging=BI, Computer Engineering=CE, Control Systems=CS, Electric Power and Power Electronics=EP, Electromagnetics and Microwaves=EM, Solid State Electronics and Electro-optics=SE and Telecommunications and Signal Processing=TS.

Ali Abur (EP)

Publications

Journals

Abur, A. and **Kezunovic, M.**, "A Simulation and Testing Laboratory for Addressing Power Quality Issues in Power Systems," IEEE Trans. on Power Systems, Vol.14, No.1, pp.3-8, Feb. 1999.

Gou B. and **Abur, A.**, "A Tracking State Estimator for Nonsinusoidal Periodic Steady-State Operation," IEEE Trans. on Power Delivery, Vol.13, No. 4, pp.1509-1514, Oct. 1998.

Magnago F.H. and **Abur, A.**, "Fault Location Using Wavelets," IEEE Trans. on Power Delivery, Vol.13, No. 4, pp.1475-1480, Oct. 1998.

Exposito, A.G. and **Abur, A.**, "Generalized Observability Analysis and Measurement Classification," IEEE Trans. on Power Systems, Vol.13, No.3, pp.1090-1096, Aug. 1998.

Books or Authoritative References

Baran, M. and **Abur, A.** "Power System State Estimation," Wiley Encyclopedia of Electrical and Electronics Engineering, Ed. by John G. Webster, University of Wisconsin-Madison.

Conference Proceedings and Presentations

Gou, B. and **Abur, A.**, "Optimal Capacitor Placement for Improving Power Quality," Paper SM 011, 1999 IEEE/PES Summer Meeting, Edmonton, Canada, July 1999.

Ozgun, O. and **Abur, A.**, "Development of an Arc Furnace Model for Power Quality Studies," Paper SM 006, 1999 IEEE/PES Summer Meeting, Edmonton, Canada, July 1999.

Magnago, F.H. and **Abur, A.**, "A New Fault Location Technique for Radial Distribution Systems Based on High Frequency Signals," Paper SM 079, IEEE/PES Summer Meeting, Edmonton, Canada, July 1999.

Abur, A., Gou, B. and Acha, E., "State Estimation of Networks Containing Power Flow Control Devices," Proceedings of the 13th Power Systems Computations Conference, Trondheim, Norway, pp.427-433, June -July 1999.

Abur, A., "Electric Power Quality," U.N. Tokten Seminar, Middle East Technical University, Department of Electrical Engineering, Ankara, Turkey, June 1999.

Gou, B. and **Abur, A.**, "A Simple Method to Determine Observable Islands for State Estimation," The International Symposium on Circuit and Systems, Orlando, May -June 1999.

Kezunovic, M., **Huang, G.**, **Abur, A.**, Bose, A., Tomsovic, K. and Venkatasubramanian, M., "Using Modeling, Simulation and Digital Simulators for Power Engineering Education," 3rd Int'l. Conference on Digital Power System Simulators – ICDS '99, Västerås, Sweden, May 1999.

Krizan, P., Magnago, F.H. and **Abur, A.**, "A Graphical Tool for the Analysis of Network Observability Algorithms," The IEEE PES Winter Meeting, New York, N.Y., pp.502-507, Feb. 1999.

Gou, B., **Abur, A.** and **Chan, A.K.**, "Analysis of Transmission Line Faults by Prony Method," Proceedings of 30th North American Power Symposium, Cleveland State University, Cleveland, pp.99-105, Oct. 1998.

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Chang, K., A miniaturized 5.8 GHz RFID tag was developed for oil drilling equipment remote identification.

Chang, K., A 5.8 GHz circular polarized rectifying antenna was invented for wireless power transmission. The rectenna exhibited a conversion efficiency of 80 percent.

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Gupta, S., "A Client Oriented, IP Level Redirection Mechanism," Aug. 1998, Chair: **A.L.N. Reddy**.

Kunapareddy, P., "On the Performance Management of Heterogeneous Networks Using SNMP," Aug. 1998, Chair: **A.L.N. Reddy**.

Madhwaraj, A.R., "Adaptive Best Effort Protocols For Video Delivery," Aug. 1998, Chair: **A.L.N. Reddy**.

Narayanan, V., "Sender Sharing Groups in Real-Time Communication," Aug. 1998, Chair: **A.L.N. Reddy**.

Yeom, I., "Ende: An End-To-End Network Delay Emulator," Aug. 1998, Chair: **A.L.N. Reddy**.

Kini, S., "Myrinet Real Time Protocol With Flexible Routing," Dec. 1998, Chair: **A.L.N. Reddy**.

Khaleel, A., "Evaluation of Data and Request Distribution Policies in Clustered Servers," Aug. 1999, Chair: **A.L.N. Reddy**.

Moores, G., "A Static Voltage-Current Characteristic For the Low Current DC Arc," Aug. 1998, Chair: **B.D. Russell**.

Mayhugh, T. L., Jr., "Personal Communications Systems," 1999, Chair: **E. Sánchez-Sinencio**.

Lei, J., "New Methodologies and Their Implementations for Integrated Circuit Design for Quality and Manufacturability," Dec. 1999, Chair: **C. Singh**.

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Hinson, B., "Generation of High-Power, High Repetition-Rate Pulses Using Erbium-Doped Fiber Ring Laser," Dec. 1998, Chair: **C.B. Su**.

Lee, J., "Fiber Optic Hydrophone Sensor Arrays Using Low Reflectance Internal Mirrors," Aug. 1998, Chair: **H.F. Taylor**.

Pillans, B.W., "Fiber Optic Diagnostic Techniques for the Electrical Discharge Machining Process," Aug. 1998, Chair: **H.F. Taylor**.

Shet, D.S., "Sensorless Position Estimation in Sinusoidal Permanent Magnet Synchronous Motor," Dec. 1998, Chair: **H. Toliyat**.

Sultana, N., "Performance Analysis of Brushless Permanent Magnet Motor (BPM) Using Load Commutated Inverter," May 1998, Chair: **H. Toliyat**.

Eiserer, R.A., "Adhesion Improvement of Electroless Copper Depositions on Titanium Nitride by Low Temperature Annealing," Aug. 1999, Chair: **M.H. Weichold**.

Babuchna, P.M., "Apparatus for Making Cathodo- and Photo- Luminescent Measurements of Thin Film Phosphors," Dec. 1998, Chair: **M.H. Weichold**.

Stoller, D. L., "Dielectric Constant Measurement of Thermoelectric Skutterudite Materials," Aug. 1998, Chair: **M.H. Weichold**.

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Spence, D., "Optimization of Shielded Birdcage Coils for MR Imaging," Dec. 1999, Chair: **S.M. Wright**.

Lebsack, E., "An Iterative Technique for Refinement of Selective Excitations for Magnetic Resonance Imaging," Dec. 1999, Chair: **S.M. Wright**.



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