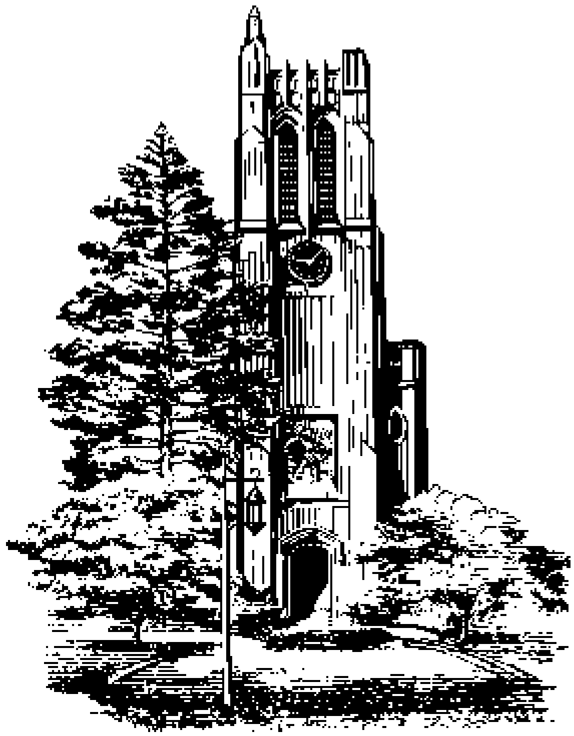
M.S. & PH.D. PROGRAMS IN ELECTRICAL ENGINEERING at Michigan State University



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MESSAGE FROM THE DEPARTMENT CHAIR

The Department of Electrical and Computer Engineering at Michigan State University has a long tradition of excellence in education and research. We believe that the background and interests of our faculty, the research facilities, and the academic excellence of our students make our department an attractive environment for graduate study. As a department, we look ahead to the future knowing that change and growth are important aspects of and inevitable in our discipline.

Prospective students should know that it is our goal to attract and educate top quality students dedicated to earning a graduate degree in electrical and computer engineering. We have designed this brochure to help prospective graduate students select an appropriate graduate program and provide information about the educational, research and financial opportunities available in the Department. While you should also consult the current graduate catalog for university and college requirements, you will find this brochure outlines the specific opportunities for graduate study in our department.

As you read this brochure and contemplate your future in graduate school, please don't hesitate to contact the department's Graduate Coordinator or any of our faculty members for more information about our graduate program. We thank you for your interest in our program and look forward to hearing from you.

Satish Udpa

NOTICE:

Deadlines for applying for admission to graduate school at Michigan State University are provided on page 34 of this Prospectus.

Additional information can be found at:

http://www.egr.msu.edu/ece/

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MICHIGAN STATE UNIVERSITY: AN OVERVIEW

A brief history: Michigan State University was founded in 1855 as the Agricultural College of the State of Michigan. The university's approach was to combine education with research and public service, which set the pattern for the entire land grant college system later established under the Morrill Act of 1863.

The Morrill Act offered an endowment to at least one college in each state "where the leading object shall be...to teach such branches of learning as are related to agriculture and the mechanic arts." On the basis of this act, the first "mechanical course" was established at MSU in 1885. Today, "mechanic arts" are known as engineering, and thus the College of Engineering looks to the land grant philosophy as its source.

MSU today: Since it's founding, MSU has grown from three buildings and five faculty members to become one of the five largest single-campus universities in the United States. It has a total enrollment of more than 42,000 students from every state in the union and 100 foreign countries and a faculty and academic staff of more than 3,000. Its undergraduate curriculum offers more than 200 programs of instruction, and graduate study is offered through some 70 departments, all taught by faculty and staff in 14 colleges. There are more than 9,000 graduate students.

MSU is one of only 54 institutions in the United States that belong to the Association of American Universities.

MSU has produced more Rhodes Scholars than any other Big 10 university in the past generation. It is also a leader in the number of students winning National Science Foundation awards and attracting National Merit Scholarship winners.

MSU libraries have a rapidly growing collection of more than 3,250,000 volumes located in the main library and 15 branch libraries, including the Engineering Library, which is located in the Engineering Building.

COLLEGE OF ENGINEERING: AN OVERVIEW

The College of Engineering today comprises the following departments: Agricultural Engineering (jointly with the College of Agriculture and Natural Resources); Chemical Engineering and Materials Science; Civil and Environmental Engineering; Computer Science and Engineering; Electrical and Computer Engineering; and Mechanical Engineering. The college also has programs in the engineering sciences and engineering arts.

Currently, the college has over 4,000 students, including over 500 graduate students. Construction on a large, futuristic engineering research facility in the southeastern part of the campus was recently completed. A major addition to the current Engineering Building was completed in 1990. The college has its own research library with more than 58,000 volumes and 630 current journal subscriptions in its collection.

In recent years, the college has received major grants from such corporations as Chrysler, Dow Chemical Company, Ford Motor Company, General Motors, Ameritech, and others.

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING: AN OVERVIEW

Electrical Engineering became a formal part of Michigan Agricultural College (MAC) in 1909 when the Division of Engineering was established. The new division had four units: civil engineering, mechanical engineering, physics, electrical engineering, and drawing and design.

The Electrical Engineering Department, separate from Physics, was established in 1916. When the present Engineering Building was opened on Shaw Lane in 1962, EE moved to the new quarters. The building has recently been expanded and a new research facility now houses several of our laboratories.

Now known as the Department of Electrical and Computer Engineering, the department currently has approximately 36 faculty members, 840 undergraduates, 86 M.S. candidates and 104 Ph.D. candidates. Graduate students in ECE quickly discover that their education is advanced in a number of ways. One of the major opportunities the department offers is the chance to work side by side with faculty members who are deeply interested in finding answers to research problems. In addition, the department regularly sponsors seminars, which bring speakers from around the U.S. to campus. Faculty, as well as students, participate in these out-of-class learning experiences.

An interdisciplinary approach marks the research projects that faculty share with their graduate students. Six current graduate study areas in the department are "Communications and Signal Processing," "Electronic Materials and Devices," "Electromagnetics," "Power Systems," "Systems and Control," "VLSI and Computer Engineering."

GRADUATE LIFE AT MSU

MSU is fortunate indeed to be located minutes away from Lansing, the capital of Michigan. The university and surrounding area provide an almost inexhaustible variety of extracurricular activities for students and their families.

Campus cultural and other special centers include the Wharton Center for Performing Arts, Kresge Art Museum, MSU Museum, Kellogg Center, Abrams Planetarium, WKAR-AM/FM public radio, and WKAR public television. Sports devotees can follow the performance of any of the 25 men's and women's intercollegiate teams on campus. Those wishing to participate in athletics can take advantage of any of the many facilities available. These include gymnasiums for basketball and racquet sports, an indoor ice-skating rink, five swimming pools, a number of outdoor tennis courts, and two 18-hole golf courses. The intramural sports program is one of the largest in the nation.

The campus, designed to be the most attractive when the university is in session, has been called "an academic park." It is a unique blend of the traditional and the innovative and is adjacent to its college town, East Lansing. The Red Cedar River traverses the campus and offers opportunities for lively activities such as canoe races or quiet reflection for those who wish to walk or study along it tree-lined shores.

The greater Lansing area, with a population of over 460,000 boasts a fine symphony orchestra which performs at the Wharton Center; several dance and theater groups, including the Boars-Head, a regional equity theatre; art galleries; the state capitol building, historical museum and library; Impression Five, a science museum for all the family; an arboretum, a zoo, and a variety of parks; and a number of restaurants to suit most pocketbooks and tastes.

Graduate students in need of a change of scene can take the train to Chicago and Toronto from East Lansing or drive an hour or two to Ann Arbor, Grand Rapids, Frankenmuth, Marshall, or Detroit. In addition, day or weekend jaunts can be made to such attractions as Greenfield Village and the Henry Ford Museum, the Irish Hills, the Kellogg Biological Station, National and State Forests, Grand Traverse Bay, and Mackinac Island. Recreational activities in Michigan are high-lighted by water sports in the summer months and skiing in winter.

FACULTY: THEIR RESEARCH INTERESTS AND LABORATORIES

THE FACULTY

Listed below are the Electrical and Computer Engineering Department faculty and some important information about them. The citations contain faculty names followed by their current academic ranks, highest degrees awarded, universities where they earned the degrees, year the degrees were earned, a brief description of their current research interests, their telephone numbers, and their email addresses.

Aslam, Dean M. – Associate Professor; Ph.D., Aachen, 1983. Diamond microsensors, field emitters and MEMS, diamond FED, SiC thermistors. [517-353-6329, aslam@egr.msu.edu]

Asmussen, Jes – Richard M. Hong Professor and University Distinguished Professor; Ph.D. Wisconsin, 1967. Plasmas, microwave processing of materials, ion and electrothermal thrusters. [517-355-4620, asmussen@egr.msu.edu]

Aviyente, Selin – Assistant Professor; Ph.D., University of Michigan, 2002. Signal processing, nonstationary signal analysis methods, application of information theory to anaylsis and classification, algorithms for computation of time-frequency distributions, applications of signal processing on biological signals. [517-355-7649, aviyente@egr.msu.edu]

Ayres, Virginia – Associate Professor; Ph.D., Purdue University, 1985. Electronic/structural properties and biocompatibility of nanostructures, growth mechanisms of carbon nanostructures, amorphous tetrahedral carbon, diamond, and silicon nanowires, site-specific scanning probe microscopy, and nanomanipulation. [517-355-5236, ayresv@egr.msu.edu]

Balasubramaniam, Shanker – Associate Professor; Ph.D., Pennsylvania State University, 1993. Applied electromagnetics, fast algorithms for transient and frequency domain solutions, computational techniques in materials, and optics. [517-432-8136, bshanker@egr.msu.edu]

Biswas, Subir – Associate Professor; Ph.D., University of Cambridge, 1994. Wireless data networking, low-power network protocols and algorithms, sensor networks, wireless Ad-Hoc networks, QoS-middleware for resource-constrained networks, control-plane network security, architecture and protocols for targeted content delivery in mobile networks. [517-432-4614, sbiswas@egr.msu.edu]

Deller, John R. – Professor; Ph.D., University of Michigan, 1979. Speech processing, system identification and adaptive filtering, biomedical applications of signal processing. [517-353-8840, deller@egr.msu.edu]

Fisher, P. David – Emeritus Professor; Ph.D., Johns Hopkins University, 1967. Digital circuit design, prototyping and emulation, instrumentation, experimental methods. [517-355-5241, fisher@egr.msu.edu]

Goodman, Erik – Professor; Ph.D., University of Michigan, 1972. Genetic algorithms, design optimization, manufacturing optimization, environmentally conscious manufacturing. [517-355-6453, goodman@ egr.msu.edu]

Grotjohn, Timothy – Professor; Ph.D., Purdue University, 1986. Plasma-assisted materials processing, plasma source design, modeling, diagnostics and applications, microwave plasmas, miniature and micro plasmas, computational modeling of plasma. [517-353-8906, grotjohn@egr.msu.edu]

Hogan, Timothy – Assistant Professor; Ph.D., Northwestern University, 1996. Charged transport measurements, pulse laser deposition of new electronic materials. [517-432-3176, hogant@egr.msu.edu]

Kempel, Leo – Associate Professor; Ph.D., University of Michigan, 1994. Electromagnetic theory; computational electromagnetics; finite element methods; large-scale scientific computing; antenna analysis and design; scattering. [517-353-9944, kempel@egr.msu.edu]

Khalil, Hassan – Professor; Ph.D., University of Illinois, 1978. Nonlinear control, singular perturbation methods, robust control. [517-355-6689, khalil@egr.msu.edu]

Li, Tongtong – Assistant Professor; Ph.D., Auburn University, 2000. Digital communications and signal processing, wireless and wireline communications, information theory, coding and decoding, networking. [517-355-7688, tongli@egr.msu.edu]

Mason, Andrew – Assistant Professor; Ph.D., University of Michigan, 2000. Mixed-signal integrated circuits, microsystems, microsensors, and micro-electro-mechanical systems (MEMS). [517-355-6502, mason@egr.msu.edu]

Mahapatra, Nihar – Associate Professor; Ph.D., University of Minnesota, 1996. Parallel and high-performance computing, computer architecture and VLSI, and dependability. [517-432-4617, nrm@egr.msu.edu]

McGough, Robert – Assistant Professor; Ph.D., University of Michigan, 1995. Research interests include medical ultrasound for thermal therapy, diagnostic imaging, and heat-mediated drug delivery. [517-432-3333, mcgough@egr.msu.edu]

Mukkamala, Ramakrishna – Assistant Professor; Ph.D., Massachusetts Institute of Technology, 2000. Biomedical signal processing and identification, modeling of physiologic systems, and cardiovascular physiology. [517-353-3120, rama@egr.msu.edu]

Nyquist, Dennis – Emeritus Professor; Ph.D., Michigan State University, 1966. Electromagnetic theory, radiation, scattering, layered media, integrated circuits, guided-wave optics. [517-355-1771, nyquist@egr.msu.edu]

Nogami, Jun – Associate Professor; Ph.D., Stanford University, 1986. Epitaxial growth on silicon surfaces, semiconductors surface atomic structure, STM measurements of dynamical phenomena at surfaces, atomistic modeling of growth on surfaces, self-assembled atomic scale structures. [517-353-3703, nogami@egr.msu.edu]

Oweiss, Karim – Assistant Professor; Ph.D., University of Michigan, 2002. Statistical array signal processing, multiresolution analysis and wavelet coding, information theory, biosignal analysis in microsystems, applications in neurophysiology and bioengineering. [517-432-8137, koweiss@egr.msu.edu]

Peng, Fang Zheng – Associate Professor; Ph.D., Nagaoka University of Technology, Japan, 1990. Power electronics, motor drives, hybrid electric vehicles, renewable energy interface systems. [517-432-3331, fzpeng@egr.msu.edu]

Pierre, Percy – Professor; Ph.D., Johns Hopkins University, 1967. Communications theory, stochastic processes, signal detection and estimation. [517-432-5148, pierre@egr.msu.edu]

Radha, Hayder – Associate Professor; Ph.D., Columbia University, 1993. Coding and communications, image and video compression, image processing, multimedia communications over packet networks, video coding and communications over the Internet and wireless networks, modeling and analysis of the stochastic behavior of communication networks, wavelet, sub-band, and multiresolution coding. [517-432-9958, radha@egr.msu.edu]

Ramuhalli, Pradeep – Assistant Professor, Ph.D., Iowa State University, 2002. Digital signal processing, neural networks, pattern recognition, electromagnetics, applications in nondestructive evaluation. [517-432-4615, rpradeep@egr.msu.edu]

Reinhard, Donnie – Graduate Coordinator and Professor; Ph.D., MIT, 1973. Electronic and optical materials and devices, low-temperature deposition and development of optical quality diamond, optical applications of thin-film diamond, application and synthesis of microstructures. [517-355-5214, reinhard@egr.msu.edu]

Ren, Jian – Assistant Professor; Ph.D. Xidian University, 1994. Computer engineering, communication networks, network security, cryptographic algorithms and protocols, error control coding. [517-353-4379, renjian@egr.msu.edu]

Rothell, Edward – Professor; Ph.D., Michigan State University, 1985. Transient electromagnetic scattering, antennas, radar target identification, electromagnetic theory. [517-355-5231, rothwell@egr.msu.edu]

Salem, Fathi – Professor; Ph.D., U.C. Berkeley, 1983. Neural Networks and learning algorithms, microelectronics VLSI and MEMS neural systems, adaptive nonlinear processing and control, optimization and optimal control. [517-355-7695, salem@egr.msu.edu]

Schlueter, Robert – Professor; Ph.D., Polytechnic Institute of Brooklyn, 1972. Bifurcation theory based autonomous agents in power systems, scheduling control and stabilization of power systems, nonlinear and intelligent control applied to power systems. [517-355-5244, schluete@egr.msu.edu]

Shanblatt, Michael – Professor; Ph.D., University of Pittsburgh, 1980. Computer engineering, VLSI architectures for enhanced control, neural networks, VLSI design methodologies. [517-353-7249, mas@egr.msu.edu]

Strangas, Elias – Associate Professor; Ph.D., University of Pittsburgh, 1980. Electrical machinery, finite-element methods for electromagnetic fields, electrical drives, power electronics. [517-353-3517, strangas@egr.msu.edu]

Udpa, Lalita – Professor; Ph.D., Colorado State University, 1986. Electromagnectic fields and waves, computational methods for electromagnetics, pattern recognition and digital signal processing. [517-355-9261, udpal@egr.msu.edu]

Udpa, Satish – Chairperson and Professor; Ph.D., Colorado State University, 1983. Nondestructive evaluation, electromagnetics, signal processing, pattern recognition, and numerical analysis. [517-432-4787, udpa@egr.msu.edu]

Wierzba, Gregory – Associate Professor; Ph.D., University of Wisconsin, 1978. Analog electronics, macromodeling, computer-aided design, active filters. [517-355-5225, wierzba@egr.msu.edu]

Xi, Ning – Associate Professor; D.Sc., Washington University (St. Louis), 1993. Control theory and applications, robotics system planning and control, manufacturing automation, network communication, microsystem design and applications, and real-time system design and implementation. [517-432-1925, xin@egr.msu.edu]

Zhong, Peixin – Assistant Professor; Ph.D., Princeton University, 1999. Computer aided-design of circuit and systems, computer architecture and system architecture and design, semiconductor materials, devices and physics, computer languages, protocols and software tools. [517-432-4616, pzhong@egr.msu.edu]

RESEARCH FACILITIES

The department's modern, well-equipped research facilities provide graduate students and their faculty advisors with resources necessary to validate theoretical concepts and to demonstrate the practical application of these concepts. In addition, these facilities spawn technological innovations in such areas as electrophysics; electronic devices and circuits; networks, systems, and control; power and robotics; signal processing; and computer engineering. Specific research facilities are identified below.

- Electromagnetic Radiation and Scattering
- Microwave/Millimeter-Wave Circuits
- Electromagnetic Materials Characterization
- Plasma and Electromagnetic Materials Processing
- Electromagnetic Process Control
- Microfabrication Cleanroom
- Microsensor Characterization
- Electronic Devices and Circuits Testing
- Nonlinear Adaptive Systems
- Electronics Research and Development
- Prototyping and Emulation
- Instrumentation and Design and Testing
- Scalable Computing Systems
- Microelectronic Neural Systems
- Electrical Machines and Drives
- Power System
- Sensor Based Robotics
- Speech Processing
- Adaptive Signal Processing
- Robotics and Automation
- Genetic Algorithms
- Scanning Probe Microscopy
- Molecular and Electronic Structure Characterization
- Pulsed Laser Vapor Deposition
- Charge Transport Characterization
- Fraunhofer Center for Coatings and Laser Applications

AREAS OF SPECIALIZATION

SIGNAL PROCESSING AND COMMUNICATIONS AREA

A. Introduction

The signal processing and communications (SP&C) area includes topics related to the electrical, magnetic, optical, and computer processing of information-bearing signals. SP&C courses and research also involve techniques for modeling systems that generate and process information, and for modeling channels over which information is transmitted. Emphasis is placed on the mathematical understanding of systems, signals, and processing techniques and their practical applications.

The SP&C area has undergone explosive growth in recent decades. New computing technologies have revolutionized both long and short distance communication systems as well as the systems for performing local computations such as filtering, coding, and pattern recognition. Modern high-capacity communication channels reliably carry text, data, voice, video, and other information messages over satellite links, optical fiber networks, wireless channels, and broadband network services into the office and private homes. High-speed computers are routinely used in such practical applications as processing of medical images, speech recognition, and personal multi-media systems. SP&C applications are found in every spectral range, from low frequency biological or geophysical signals, to audio and video bands, and on up to the microwave and optical bands.

Interest in information processing technology represented by the SP&C area continues to grow dramatically, and engineers with graduate degrees in this area are in high demand by analog and digital communication industries, high technology research and development companies, government laboratories, universities, and many other companies with information and data handling needs.

B. Research Areas at MSU

Research in SP&C at MSU is best characterized by the term "statistical signal processing." This term is becoming universally used to designate a broad subdiscipline concerned with signal processing in the presence of changing uncertainties (noisy channels, uncertain models, etc.). The focus of statistic signal processing is upon mathematical techniques that provide adaptively optimal solutions in the presence of the non-ideal conditions occurring in real problems. Applications of statistical signal processing results are very broad. Current MSU research involves speech recognition, biomedical signal processing, communication channel modeling, array processing, speech and image coding, neural network training algorithms, and wavelet and multirate systems. Opportunities exist for SP&C research students to interact with many faculty in related areas such as embedded computing systems, VLSI and parallel architectures, and pattern recognition.

VLSI and COMPUTER ENGINEERING AREA

A. Introduction

As we enter a new century we are witnessing a period of radical development in computer architectures, the proliferation of embedded computers and entire systems being built on a single chip. This has come about because of the remarkable advances in integrated circuit processing technology that have seen dramatic increases in chip complexities, while the manufacturing cost of a chip has remained fairly constant. It has been predicted that this trend will continue unabated with best estimates placing the theoretical limit at about 10^8 gates per chip. But what can we do with this technology? How can we best use it? Students specializing in computer engineering at Michigan State University are developing the theoretical foundation and practical hands-on experience necessary to answer these questions.

Graduate program coursework at the M.S. and Ph.D. levels is taken in both the Electrical and Computer Engineering (ECE) and Computer Science (CSE) Departments. Courses focus on advanced digital electronic circuit design, contemporary computer-aided design tools and methodologies, design of systems using embedded processors, fault-tolerant and packaging design issues, advanced topics in computer architecture, performance evaluation of computer systems, the design, test and packaging of application-specific integrated circuits (ASICs), hardware/software co-design, artificial intelligence, operating systems switched capacities circuits, mixed signal and analog circuits, and network synthesis. Independent study courses may be taken in either department with a student and faculty member working one-on-one to explore in depth a subject of mutual interest.

B. Research Opportunities

Research opportunities in computer engineering at MSU are varied and deal with challenging problems centered on the electronics, architecture, design and configuration of computers. Faculty and graduate students work together and in multidisciplinary teams on these research problems with funding coming from a variety of governmental agencies and private industry.

Challenging research emphasis is available on topics such as hardware-software co-design, computer architecture, computer performance evaluation and visualization, embedded real-time system analysis, logic design and VLSI implementation, embedded systems, rapid prototyping, circuit testing and design verification, multi-chip module and MEMS hardware; mixed-signal IC design and testing; deep sub-micron design and analysis, computer architecture and networks, fault-tolerant systems, BIST design for embedded systems, low-power physical design and design automation, fault-tolerant embedded systems, defect-tolerant micro-electronics structures, and digital logic synthesis. Research in the area of electronic circuit and network design includes analog integrated circuit design, development and use of computer-aided engineering tools, circuit design using standard integrated circuits, development of macromodels of analog integrated circuits and synthesis of high frequency active filters.

C. VLSI and Computer Engineering Education at MSU

Excellent facilities are available for students interested in computer engineering; these afford many opportunities to gain valuable practical experience. Facilities available to graduate students in computer engineering include a campus-wide broadband network to access all of the university's computing resources and the Internet. Numerous laboratories are available with computational facilities including UNIX-based SUN workstations and a multitude of personal computers. Other project-specific labs available for student use include CAE facilities for designing ASICs, hardware prototyping and emulation facilities, and facilities with state-of-the-art analog and digital test equipment. Specific graduate teaching and research laboratories include the Electronics Research and Development Laboratory (ERDL), the Instrumentation Design and Testing Laboratory (IDTL), the Distributed Computer Research Laboratory (DCRL), a mini-/micro-computer research laboratory, a pattern recognition laboratory, and a computer performance laboratory.

SYSTEMS and CONTROL AREA

A. Introduction

The field of control has a rich heritage of intellectual depth and practical achievements. From the waterclock of Ktesibios in ancient Alexandria to the space probes of today, control systems have played a key role in technological and scientific development. Since the 1960's, there have been many challenges and spectacular achievements in space and aeronautics. Control systems are providing new opportunities in the automotive industry, consumer products, process control, nuclear reactor control, power systems, robotics, manufacturing and defense areas, to name a few.

B. Research Areas at MSU

Robust and adaptive control: Models of realistic systems are seldom completely known. Control theorists are now challenged to extend their concepts and methods to be applicable to incompletely modeled systems. Robust control characterizes the uncertainty in the model of the plant to be controlled and evaluates the degrees of freedom left to achieve the control task within specified bounds. Adaptive control, on the other hand, makes use of the most structured type of plant uncertainty in which the plant model has a known form, but unknown parameters. One pressing challenge for researchers in this field is to develop modified or new adaptive schemes, which would successfully prevent the rise of instabilities in the face of disturbances and/or unstructured, unmodeled dynamics. The theory is extended to nonlinear systems using high-gain observers and singular perturbation techniques.

Starting with experiences from adaptive control, researchers are now moving towards "intelligent control" attempts to mimic the human performance in multiple or parallel decisions in a variety of situations. Although there is no existing theory for intelligent control, it is anticipated that research in the area of neural networks and expert systems may shed some light on the development of self-organizing architectures capable of executing "intelligent" decisions.

Qualitative analysis of nonlinear dynamical system: The thrust of research in this area aims at identifying nonlinear systems structures for which parameter changes or the occurrence of unexpected disturbance ought not to alter the qualitative behavior of the system. More specifically, one seeks to understand all possible qualitative behaviors of certain nonlinear systems because some or all of its parameters are varied.

C. Control Education at MSU

Systems and control courses provide a strong analytical foundation in linear systems, multi-variable control, nonlinear systems, nonlinear control, optimal control, adaptive control, stochastic processes, and identification. This theoretical foundation is supported with application courses in robotic control, control of power systems, control of electrical drives and laboratory opportunities in a control and robotics lab, and a microprocessor-based system design lab.

ENGINEERING ELECTROSCIENCES AREA

A. Introduction

Graduate-level specialization in the engineering electrosciences includes electromagnetics and electronic materials and devices. This specialty area encompasses course offerings and research that embrace contemporary topics in electromagnetics, electro-optics, electronic devices, semiconductors and plasmas. Research activities include both analytical and experimental studies within each of these component areas. Graduate students plan their M.S. or Ph.D. programs by selecting from comprehensive graduate course offerings. Fundamental electroscience concepts are treated in Master's level courses while advanced research development courses support the various research specializations. Modern laboratories are available to support research in the electrosciences. Available coursework and research experiences prepare the Master’s level graduate for industrial design or development activities and the doctoral-level graduate for research at university or industrial/government laboratories.

B. Research Areas at MSU

The electromagnetics (EM) area enjoys national recognition in the study and application of electromagnetic fields and waves. Course offerings include: EM theory, guided waves/microwave circuits, Fourier optics, planar waveguides, antenna theory and diffraction. Research facilities include three antenna/scattering ranges (anechoic chamber, ground-plane, and free-field arch), a millimeter-wave lab, and facilities for studying the interaction of EM fields with biological systems. In addition, a dedicated computer network has recently been installed for computational electromagnetics research. Research projects include: transient wave scattering for target identification and imaging, interactions of EM fields with biological systems, guided/scattering waves from open waveguides, EM characterization of materials, microwave material processing, and antenna and scattering analysis/design.

The electronic materials and devices area includes processing, which is concerned with microwave plasma chemistry, plasma processing, and electromagnetic processing of polymer/composite and ceramic materials. Processing research projects focusing on the invention, design, and application of microwave technologies have received national attention. Specific research projects include: microwave plasma-assisted chemical vapor deposition of diamond, plasma-assisted etching for submicron integrated circuits, microwave solid materials processing including the sintering and joining of ceramics, microwave applicator design and modeling for plasma generation and materials processing, microwave plasma ion source design and process applications. The area also includes device oriented research, including design and fabrication of MEM’s including MEM’s in wireless systems, development of microsensors for pressure and temperature, investigation of new field emitter displays, modeling and simulation of sub-micron devices, and research of on-wafer optical materials and devices, particularly diamond related.

POWER AREA

A. Introduction

The work in the power area involves courses and research on power systems, electrical machines, and electric drives.

Deregulation will result in (a) less predictability of both load and generation and (b) larger power transfers across utility boundaries. These factors have introduced the threat of new and different stability problems. New methods of stabilizing and operating the power system are required to solve these stability problems. Intelligent control to determine the location, and subsystems initiating possible blackouts, the equipment outages that produce them, and a diagnostic for deciding the cause and cure will be required to maintain high levels of reliability utility customers have come to expect. Intelligent control is also needed to develop scheduling dispatch, and stabilization methods appropriate to a deregulated power industry.

Rapid advances in semiconductor and computing technology and the demand for higher efficiency and better control has led to the integration of power semiconductors into loads (for example: motor drives, process and illumination controllers). Work on electrical drive systems involves the design of new electrical machines tuned to the application, the development of new control methodologies to improve the response of a motor while using fewer sensors, and innovation in power electronics to reduce losses and improve response. Applications range from the automotive and aerospace industries to manufacturing and appliances. This power electronics technology is also being used to help control and stabilize the power system needed if the nations electric utility industry is to maintain our current level of reliability after deregulation is complete.

FACILITIES: The power system laboratory contains computer and power system software that are the best available and, in some cases, not available in other university power system research laboratories. The power research and teaching laboratory is one of the finest in the country. It allows the students and researchers to experiment with computer controlled electrical machines, drives, and power electronics systems.

B. Research Areas at MSU

The faculty members are actively pursuing research that addresses the problems associated with 1) power system analysis for scheduling, control, and stabilizing power systems; 2) developing improved motors, power electronic drives, and converters; and 3) improving distribution and customer system operation and protection. Current research opportunities in each of these three areas are listed below:

- (a) Solution of electromagnetic fields in machines and transformers;
- (b) Power electronics in motors and power systems;
- (c) Motor drives and controllers
- (d) Special purpose machines
- (e) Stability of Power Systems
- (f) Security and Stability Assessment and Diagnosis
- (g) Intelligent Control of Power Systems
- (h) Operation of Power Systems

M.S. IN EE --- SAMPLE PROGRAMS

The objective of this sample program guide is to assist M.S. students in selecting courses that meet their individual needs and objectives and meet college and departmental requirements. Each student, with the approval of the Academic Advisor, should select a program of study that complements the student's prior background and provides the breadth needed to successfully complete the qualifying examination.

The department's course offerings at the 400, 800, and 900 levels may be grouped in a variety of ways to emphasize subject area content. The following is one such grouping provided to enable students to choose enriching experiences in certain areas:

Applied Electromagnetics – 405, 407, 835, 836, 841, 850, 929, 989

Electronic Devices and Materials – 474, 476, 477, 874, 875, 931

Electric Power – 421, 821, 823, 824, 825, 925

Controls and Systems – 415, 818, 826, 829, 859, 960, 963

VLSI and Computer Engineering – 410, 411, 418, 484, 807, 808, 809, 813, 820, 822, 831, 832, 920, 921

Signal Processing and Communications – 457, 458, 466, 863, 864, 865, 966

Students wishing additional information about the content of a course should consult the **DESCRIPTION OF COURSES** on the MSU web site. Also, students are encouraged to read the syllabus, talk with the instructor, and seek the advice of their academic advisor.

The sample programs, which follow, are prepared for a student interested in completing degree requirements in three semesters. Students who wish to complete their degree requirements in longer periods can adjust these programs to their needs by recognizing prerequisites and multiple-semester offerings of some courses. The sample programs satisfy departmental core requirements and College requirements for credits at the 800 level.

M.S. Degree in Electrical Engineering with Emphasis on VLSI and Computer Engineering: A Sample Program of Study

Fall				**Credits**
1.	ECE	809	Algorithms and Hardware Implementation	**(3)**
2.	ECE	826	Linear Control Systems	**(3)**
3.	**Select one of the following:**			**(3)**
	ECE	831	Analog Circuit Theory	
	ECE	863	Analysis of Stochastic Systems	
	ECE	874	Physical Electronics	

Spring				**Credits**
1.	ECE	813	Advanced VLSI Design	**(3)**
2.	STT	441	Statistics and Probability I	**(3)**
3.	**Select two of the following:**			**(6)**
	ECE	822	Parallel Processing Computer Systems	
	ECE	829	Optimal Multivariable Control	
	ECE	864	Detection and Estimation Theory	
	ECE	875	Electronic Devices	
	ECE	921	Advanced Topics in Digital Circuits and Systems	
	CSE	802	Pattern Recognition and Analysis	
	CSE	812	Advanced Operating Systems	
	CSE	838	Design of Parallel Algorithms	

Fall				**Credits**
1.	MTH	472	Mathematical Logic	**(3)**
2.	ECE	820	Advanced Computer Architecture	**(3)**
3.	**Select one of the following:**			**(3)**
	ECE	832	Analog Integrated Circuit Design	
	ECE	835	Electromagnetic Fields and Waves I	
	ECE	874	Physical Electronics	
	CSE	422	Computer Networks	
	CSE	830	Design and Theory of Algorithms	
	CSE	835	Algorithmic Graph Theory	
	CSE	841	Artificial Intelligence	
	CSE	880	Advanced Database Systems	
			TOTAL	**(30)**

Partial List of Alternative Courses:

ECE 410 **(4)** FS, SS	ECE 847 **(3)** SS:E	CSE 480 **(4)** SS	MTH 850 **(3)** FS
ECE 411 **(4)** FS, SS	ECE 859 **(3)** SS	CSE 803 **(3)** FS	MTH 851 **(3)** SS
ECE 466 **(3)** FS	ECE 921 **(3)** SS	CSE 814 **(3)** FS:O	
ECE 474 **(3)** SS	CSE 420 **(4)** SS	MTH 424 **(3)** FS, SS, US	
ECE 841 **(3)** SS:O	CSE 449 **(3)** SS	MTH 471 **(3)** FS	

M.S. Degree in Electrical Engineering with Emphasis on Control: A Sample Program of Study

Fall				**Credits**
1.	ECE	826	Linear Control Systems	**(3)**
2.	ECE	863	Analysis of Stochastic Systems	**(3)**
3.	MTH	415	Applied Linear Algebra	**(3)**

Spring				**Credits**
1.	ECE	829	Optimal Multivariable Control	**(3)**
2.	ECE	859	Nonlinear Control	**(3)**
3.	ECE	864	Detection and Estimation Theory	**(3)**
4.	MTH	421	Analysis II	**(3)**

Fall				**Credits**
1.	ECE	960	Advanced Topics in Control	**(3)**
2.	**Select one of the following:**			**(3)**
	ECE	813	Logic Design Principles	
	ECE	835	Electromagnetic Field and Waves I	
	ECE	874	Physical Electronics	
3.	**Select one of the following:**			**(3)**
	ECE	823	Power System Stability and Control	
	ECE	824	Power System Operation and Control	
	ECE	831	Analog Circuit Theory	
	ECE	832	Analog Integrated Circuit Design	
	ECE	885	Artificial Neural Networks	
			TOTAL	**(30)**

Partial List of Alternative Courses:

ECE 410 **(3)** FS, SS	ECE 421 **(3)** SS	ECE 847 **(3)** SS:E	MTH 452 **(3)** SS
ECE 415 **(3)** FS	ECE 466 **(3)** FS	MTH 424 **(3)** FS, SS, US	MTH 461 **(3)** FS
ECE 418 **(3)** FS	ECE 813 **(3)**	MTH 451 **(3)** FS	STT 441 **(3)** FS, SS, US

M.S. Degree in Electrical Engineering with Emphasis on Signal Processing and Communication: A Sample Program of Study

Fall				**Credits**
1.	ECE	466	Digital Signal Processing & Filter Design	**(3)**
2.	MTH	428H	Honors Analysis I*	**(3)**
3.	ECE	826	Linear Systems Theory	**(3)**
4.	ECE	863	Analysis of Stochastic Systems**	**(3)**

Spring				**Credits**
1.	ECE	813	Advanced VLSI Design	**(3)**
2.	ECE	864	Detection and Estimation Theory	**(3)**
3.	MTH	828	Real Analysis I*	**(3)**

Fall				**Credits**
1.	ECE	865	Digital Communication Systems	**(3)**
2.	**Select two of the following:**			**(6)**
	ECE	835	Electromagnetic Fields and Waves	
	ECE	885	Artificial Neural Networks	
	ECE	966	Advanced Topics in Signal Processing	
			TOTAL	**(30)**

Partial List of Alternative Courses:

ECE 457 **(3)** SS	CSE 422 **(3)** FS, SS	CSE 835 **(3)** FS	MTH 810 **(3)** SS
ECE 458 **(1)** FS, SS	CSE 474 **(3)** FS	CSE 838 **(3)** FS	STT 441 **(3)** FS, SS, US
ECE 809 **(3)** SS	CSE 802 **(3)** SS	MTH 415 **(3)** FS, SS	STT 844 **(3)** SS
ECE 829 **(3)** SS	CSE 803 **(3)** FS	MTH 425 **(3)** FS, SS	STT 861 **(3)** FS
ECE 841 **(3)** SS	CSE 808 **(3)** FS:E	MTH 443 **(3)** FS	STT 862 **(3)** SS
ECE 966 **(3)** FS, SS	CSE 822 **(3)** FS	MTH 461 **(3)** FS	

*Strongly recommend for students intending to pursue the Ph.D. Students pursuing the M.S. only may elect less abstract math courses.

**Students who do not have an elementary course in probability should elect STT 441 and defer ECE 863 and ECE 864.

M.S. Degree in Electrical Engineering
with Emphasis on Power Systems, Machines and Drives
A Sample Program of Study

Fall				**Credits**
1.	**Select one of the following:**			**(3)**
	ECE	823	Power System Stability and Control (even years)	
	ECE	824	Power System Operation and Control (odd years)	
	ECE	825	Alternating Current Electrical Machines and Drives (odd)	
	ECE	826	Linear Control Systems	
2.	**Select one of the following:**			**(3)**
	ECE	809	Algorithms and Hardware Implementation	
	ECE	835	Electromagnetic Fields and Waves I	
	ECE	863	Analysis of Stochastic Systems	
3.	**Select one of the following:**			**(3)**
	MTH	424	Applied Advanced Calculus	
	MTH	421	Analysis I	
	STT	441	Statistics and Probability I	
	MTH	451	Numerical Analysis I	

Spring				**Credits**
1.	**Select the following:**			**(3)**
	ECE	925	Advanced Machines Drives (even) /Intelligent Control of Power Systems (odd)	
2.	**Select one of the following:**			**(3)**
	MTH	421	Analysis II	
	STT	442	Statistics and Probability II	
	MTH	452	Numerical Analysis II	
3.	**Select one of the following:**			**(3)**
	ECE	829	Optimal Multivariable Control	
	ECE	859	Nonlinear Control	
	ECE	864	Detection and Estimation	

Fall				**Credits**
1.	**Select two of the following:**			**(6)**
	ECE	823	Power System Stability and Control (even years)	
	ECE	824	Power System Operation and Control (odd years)	
	ECE	825	Alternating Current Electrical Machines and Drives (odd)	
2.	**Select one of the following:**			**(3)**
	ECE	809	Algorithms and Hardware Implementation	
	ECE	835	Electromagnetic Fields and Waves I	
	ECE	863	Analysis of Stochastic Systems	
			Total	**(30)**

Partial List of Alternative Courses:

ECE 421 **(4)** SS	ECE 485 **(4)** SS	MTH 422 **(3)** SS
ECE 482 **(3)** FS	MTH 421 **(3)** FS, SS, US	MTH 424 **(3)** SS, US

M.S. Degree in Electrical Engineering with Emphasis on Electromagnetics: A Sample Program of Study

Fall		**Credits**
1.	ECE 835 Electromagnetic Fields and Waves I	**(3)**
2.	ECE874 Physical Electronics	**(3)**
3.	**Select one of the following**	
	ECE 435 Electromagnetic Waves and Applications	**(3)**
	MTH 451 Numerical Analysis I	**(3)**

Spring		**Credits**
1.	ECE 836 Electromagnetic Fields and Waves II	**(3)**
2.	ECE 841 Fourier Optics	**(3)**
3.	ECE 875 Electronic Devices	**(3)**
4.	**Select one of the following**	
	ECE 850 Electrodynamics of Plasma	**(3)**
	ECE 847 Analog and Digital Communications	**(3)**
	MTH 425 Complex Analysis	**(3)**

Fall		**Credits**
1.	ECE 929 Advanced Topics in Electromagnetics	**(3-4)**
2.	ECE 842 Quantum Electronics	**(3)**
3.	**Select one of the following**	
	ECE 476 Electro-Optics	**(3)**
	MTH 443 Boundary Value Problems	**(3)**
	Total	**(30)**

Partial List of Alternative Courses

ECE 864 **(3)** SS	MTH 842 **(3)** SS	PHY 472 **(3)** SS
MTH 424 **(3)** FS, SS, US	MTH 850 **(3)** FS	PHY 841 **(3)** FS
MTH 841 **(3)** FS	MTH 851 **(3)** SS	PHY 842 **(3)** SS
PHY 425B **(3)** US	PHY 851 **(3)** FS	PHY 852 **(3)** SS

M.S. Degree in Electrical Engineering with Emphasis on Electronic Materials and Devices: A Sample Program of Study

Fall				**Credits**
1.	ECE	874	Physical Electronics	**(3)**
2.	ECE	835	Electromagnetic Fields and Waves I	**(3)**
3.	**Select one of the following:**			**(3)**
	ECE	809	Algorithms and Hardware Implementation	
	ECE	826	Linear Control Systems	
	ECE	863	Analysis of Stochastic Systems	

Spring				**Credits**
1.	ECE	836	Electromagnetic Fields and Waves II	**(3)**
2.	ECE	875	Electronic Devices	**(3)**
3.	MTH	424	Applied Advanced Calculus	**(3)**
4.	**Select one of the following:**			**(3)**
	ECE	813	Advanced VLSI Design	
	ECE	841	Fourier Optics	
	ECE	850	Electrodynamics of Plasmas	

Fall				**Credits**
1.	PHY	851	Quantum Mechanics	**(3)**
2.	**Select two of the following:**			**(6)**
	ECE	813	Logic Design Principles	
	ECE	826	Linear Control Systems	
	ECE	831	Analog Circuit Theory	
	ECE	832	Analog Integrated Circuit Design	
	ECE	863	Analysis of Stochastic Systems	
			TOTAL	**(30)**

Partial List of Alternative Courses:

ECE 410 **(3)** FS, SS	ECE 476 **(3)** FS	ECE 847 **(3)** SS:E	MTH 451 **(3)** FS
ECE 411 **(3)** SS	ECE 477 **(3)** FS, SS	ECE 859 **(3)** SS	MTH 452 **(3)** SS
ECE 418 **(3)** FS	ECE 483 **(4)** FS	ECE 866 **(3)** SS	MTH 850 **(3)** FS
ECE 435 **(3)** FS	ECE 813 **(3)** FS	ECE 931 **(3)** FS, SS	STT 441 **(3)** FS, SS, US
ECE 474 **(3)** SS	ECE 829 **(3)** SS	MTH 443 **(3)** FS	

M.S. PROGRAM REGULATIONS

The main purpose of this document is to inform a Master of Science in Electrical Engineering degree candidate of requirements specific to the Electrical and Computer Engineering Department. However, for convenience, selected highlights of the university and college regulations are also included as well as some general guidelines and sample programs of study.

It is quite important to also read the university and college requirements for M.S. students, which are separate documents. The student should note that department regulations may be more stringent than general college requirements, and that college regulations may be more stringent than general University requirements.

Questions concerning these regulations should be directed to either the graduate student's academic advisor or the department's Graduate Program Coordinator.

1. Upon enrollment in the M.S. degree program each student shall meet with the Graduate Coordinator who will work with the student to discuss program regulations, to plan the courses for the initial semester and to assign an academic advisor to the student. The academic advisor and the student plan the M.S. degree program in accordance with the provisions of "M.S. Degree Program Regulations" as adopted by the college. The "M.S. Degree Program Plan" must be submitted before the student completes six credits of graduate work. All courses contributing to the total credits listed on this form must be taken under the numerical grading system. No course may be repeated for which a student received a grade of 2.0 or above.

2. Any modifications to the Masters Degree Program Plan are submitted with the approval of the Academic Advisor. In seeking program changes for courses in which a student is currently enrolled, the Advisor's approval must be obtained no later than the deadline for drops and adds. **No change in the program will be approved which adds or deletes a course in which a grade (including "Deferred") has already been received. See also the additional College regulations regarding program modification.**

3. A maximum of 9 credits of transfer work may be approved. The completed form "Credit Evaluation--Graduate Program" must be included with any program specifying transfer credit. Transfer credits shall be given only for courses not taken while meeting B.S. or ***other*** degree requirements.

4. The diploma card must be completed by the student when registering for the final semester.

5. All deferred grades must be cleared at least two weeks before the end of the final semester.

6. If a thesis is completed (Plan A), it will be defended in an oral M.S. thesis exam. The examining committee shall be composed of at least three persons. Two of these persons shall be Michigan State University regular faculty and one shall be the thesis advisor. The student and thesis advisor shall form the examining committee with the approval of the department's Graduate Coordinator. Copies of the thesis will be provided as follows:

    a. An unbound, original copy with abstract and thesis plate to the Graduate School.
    b. A hard bound copy to the ECE department.
    c. A hard bound copy to the M.S. thesis advisor.

(See also, **The Formatting Guide for thesis and dissertations**, an MSU Publication, for guidelines in preparing the M.S. thesis.)

7. The minimum requirements for a person seeking a Second M.S. degree in Electrical Engineering (i.e., a person who has obtained or is seeking a graduate degree in another department at MSU, the non-ECE program being a student's primary program) are:

   - At least 21 credit hours of material related to electrical engineering and not included in the student's other graduate degree program.
   - At least 12 credits of the program must involve courses for which a grade has not yet been received prior to admission. (This will also hold for students changing majors within Michigan State University on a 1st M.S. program).
   - An ECE advisor must be assigned and a second M.S. program must be filed before half of the required 21 credits of related ECE course material are completed.

8. Core Course Requirements for the M.S. in Electrical Engineering, students are required to take a minimum of 4 total core courses from a minimum of 2 areas.

   Communication & Signal Processing: ECE 863, ECE 864, ECE 865
   Electronic Materials and Devices: ECE 850, ECE 874, ECE 875
   Electromagnetics: ECE 835, ECE 836, ECE 841
   Power Systems: ECE 823, ECE 824, ECE 825
   Systems & Control: ECE 826, ECE 829, ECE 859
   VLSI and Computer Engineering: ECE 809, ECE 813, [ECE 820/831/832]*

   *Only one of the course in these brackets may be counted toward the 4-course total.

9. At least 6 credits in areas such as Mathematics, Statistics, and Physics are required. Examples of approved courses are as follows.

   MTH 415, 421, 424, 425, 428H, 443, 451, 452, 461, 472
   MTH 810, 828, 829, 841, 842, 848, 849, 850, 851, 852, 881
   STT 441, 442, 844, 861, 862
   PHY 425B, 471, 472, 810, 841, 842, 851, 852

10. Seminar requirement: First year graduate students are required to attend 7 graduate seminar series. All other graduate students are encouraged to attend.

11. Proficiency requirement: Students whose undergraduate degree is not in Electrical or Computer Engineering, must demonstrate proficiency in 3 out of the following courses; ECE 302, ECE 305, ECE 313, ECE 360.

12. The college and university M.S. program regulations address all of the additional requirements for the M.S. degree. These include time limitations, grade-point average for graduation, grade-point calculation, acceptable grades, limitations on deferred grades, probational status, retention in program, examinations, evaluation, and thesis requirements. Students should consult the appropriate college and university documents for details.

M.S. PROGRAM REGULATIONS --- COLLEGE OF ENGINEERING
(SELECTED HIGHLIGHTS)

This section provides a few highlights from the document entitled, **Academic Programs**. Consult this document for a complete set of college requirements.

1. **Admission**

   There are two possibilities for degree candidates:

   a. Regular Status

   b. Provisional Status. This indicates either that collateral work is required, or that the student's record has not yet been fully evaluated.

2. **Programs of Study**

   a. A minimum of 30 credits beyond the B.S. degree are required for a first M.S. degree.

   b. A thesis option is available in which from 4 to 8 thesis credits may be taken as part of the 30 credits.

   c. At least 20 credits (with thesis) or 18 credits (without thesis) must be at the 800 or 900 level.

   d. The program must be completed within 5 years.

   e. See Department Regulations for a second M.S. degree.

   f. See Department Regulations for transfer credits.

3. **Grades**

   a. At least a 2.0 is required for any course on the student's program.

   b. If the accumulated grade point average drops below a 3.0 the student is placed on probation. This grade point average does not include transfer credits or collateral work.

   c. An accumulated grade point average greater than or equal to 3.0 on all programmed work is required to graduate. Courses not on the program do not affect graduation.

4. **Modification of Program**

   With reference to the student’s approved program of study, none of the following types of changes will be approved:

a. Adding or deleting a course for which a grade has already been assigned under any of the three grading systems (numerical, Pass – No Grade, or Credit – No credit).

b. Adding or deleting a course for which grading was postponed by the use of the DF – Deferred marker.

c. Adding or deleting a course which the student dropped after the middle of the semester and for which "W" or "N" or "0.0" was designated.

d. Adding or deleting a course during the final semester of enrollment in the master's degree program.

M.S. PROGRAM REGULATIONS --- UNIVERSITY (SELECTED HIGHLIGHTS)

This section provides selected highlights from the university publication entitled, **Academic Programs**. Consult this document for a complete set of university requirements.

1. **Graduate Assistants**

   a. A quarter time assistant must be enrolled for at least six, but not more than sixteen credits.

   b. A half time assistant must be enrolled for at least six, but not more than twelve credits.

   c. A three quarter time assistant must be enrolled for at least three, but not more than eight credits.

   d. Exceeding maximum credit limits requires written approval from the Graduate School.

2. **Full-Time Students (no assistantship)**

   a. In order to be considered a full time student, for academic purposes, a minimum of nine credits is required.

   b. A student load above sixteen credits requires written approval from the Dean.

3. **Residency**

   At least nine credits must be taken in residence.

4. **Minimum Registration**

   There is a minimum registration fee of one credit.

PH.D. PROGRAM REGULATIONS

1. Admission Requirements

Requirements for admission into the department's Ph.D. program are fully described in the college's Ph.D. program regulations.

2. Guidance Committee

Program regulations regarding the formation and activities of the Ph.D. student's guidance committee are fully described in the college's Ph.D. program regulations.

3. Course Requirements

3.1 **General Course Requirements:** The doctoral program must minimally include forty-two (42) credits, exclusive of any independent study credits, beyond the B.S. degree in 800/900 level courses. A minimum of six (6) of these credits must be taken in mathematics, statistics, or physics. All such courses must be taken under the numerical grading system with the exception that up to three (3) Masters thesis credits may be applied to the Ph.D. course requirement. Courses will be prescribed by the guidance committee to ensure that the student has a comprehensive knowledge of a major research field and related subjects. The required courses will depend upon the student's academic background in relation to the selected research specialization.

3.2 **Non-Technical Requirement:** A student's guidance committee shall determine whether or not a need exists for collateral work in language, written or oral communication, or other non-technical areas. After review, the guidance committee may establish a corresponding requirement.

3.3 **Research Credit Requirement:** In addition to the credits required in Sections 3.1 and 3.2, all doctoral students must register for at least 24 credits of doctoral thesis research (EE 999).

3.4 **Transfer Credit:** Transfer work beyond the M.S. degree may be approved if it is considered appropriate to the candidate's program. In general, up to 50 percent of course work beyond the M.S. degree may be transfer credits; credits will be given only for courses in which a grade of 3.0 (B) or better was earned. After approval by the guidance committee, requests for transfer of credit from other institutions will be submitted on Form R76-C155, "**Credit Evaluation-Graduate Program.**"

3.5 **Special Problems and Selected Topics Courses:** Special problems and selected topics courses listed on the program will give the subject and the instructor.

3.6 **Modification of Program:** Any modification to the doctoral program will be submitted to the Dean with approval of the guidance committee and department Chairperson using

Form VI-A. No change in the program will be approved which adds or deletes a course for which a grade has been received.

3.7 **Seminar requirement:** First year graduate students are required to attend a graduate seminar series. All other graduate students are encouraged to attend.

4. Qualifying Examination

4.1 **Objective:** The intent of the Ph.D. qualifying examination (the exam) is to assess a student's potential for successfully completing doctoral-level studies and research in the department.

4.2 **Format:** The exam shall consist of two parts. Part A will be written and closed book and will be prepared by groups of faculty selected by the Graduate Studies Committee. Part B will have written and oral components and will be based on a research project conducted by the student under the guidance of a faculty advisor.

4.3 Part A

4.3.1 **Format**: The exam will last three hours and will consist of one set of questions in each of the two core areas:

Circuit Fundamentals
Digital Logic Fundamentals

And one set of questions in each of the six focus areas:

Computers
Control
Electromagnetics
Electronic Devices
Signal Processing & Communication
Power Systems

Each set will be broad, based on undergraduate background, and workable in 30 minutes. Each student must work the two core areas and three areas chosen from the six focus areas. Only those areas identified by the student to be graded will be graded.

4.3.2 **Evaluation**: The department's Graduate Studies Committee will evaluate the student's performance in Part A of the exam. Decisions by the committee will fall into one of the following four categories:

QP3. A student passes part A of the exam and is encouraged to continue in the Ph.D. program and take part B of the exam.

QP2. A student passes part A of the exam but is required, on the basis of the student's total record, to take prescribed class(es). Moreover, the student is encouraged to continue in the Ph.D. program and take part B of the exam.

QP1. A student does not pass part A of the exam but is encouraged, on the basis of the student's total record, to retake the exam the next time it is offered.

QP0. A student does not pass part A of the exam and is asked, on the basis of the student's total record, to withdraw from the Ph.D. Program at the end of the present semester.

In arriving at its decision, the committee will use a numerical score on a scale of zero to 100, based on 20 points per area. Students will fall into one of three groups:

a. A student with a score of 70 or higher will receive QP3.
b. A student with a score less than 50 will receive QP1 or QP0.
c. The decision for a student with a score less than 70 but greater than or equal to 50 could be QP3, QP2, QP1, or QP0.

The committee will use the following information as it formulates its decision for students in group b or c:

a. An evaluation of the student's prior undergraduate and graduate academic record.
b. Grades in the graduate program with course level, course load and workload considered.
d. Evaluation by faculty who have had the student in class or on teaching or research assignments.
e. Performance on part A of the exam.

4.3.3 **Schedule:** Part A of the Exam is offered twice a year, in the third week of the fall and spring semesters. All Ph.D. program students are required to take the exam no later than the first offering after completing their first semester in the program. In exceptional cases, an appeal may be made to the Graduate Studies Committee for postponement of this scheduling requirement.

4.4 Part B

4.4.1 **Format**: After passing part A of the exam, the student will choose a faculty advisor to supervise part B of the exam. The faculty advisor will assign a research topic to the student, who will research the topic, submit a written report describing his/her approach to addressing the research problem, and make an oral presentation in front of an evaluation committee.

4.4.2 **Evaluation**: The Graduate Coordinator will form a committee of three ECE faculty members, one of them being the advisor, to evaluate the written report and the oral presentation. Decisions by the committee will fall into one of the following three categories:

a. A student passes part B of the exam and is encouraged to continue in the Ph.D. program, form a guidance committee if one does not already exist, and begin preparation for the comprehensive exam and thesis research.
b. A student does not pass part B of the exam but is granted an extension, up to a month, with conditions and/or requirements specified by the committee.

c. A student does not pass part B of the exam and is asked to withdraw from the Ph.D. Program at the end of the present semester.

All three members of the committee must approve a pass outcome. For an extension outcome, all members must be voting for pass or extension.

4.4.3 **Schedule**: After passing part A of the exam, the student has until the end of the next semester to finish part B. In exceptional cases, an appeal may be made to the Graduate Studies Committee for postponement of this scheduling requirement.

4.4.4 **Waiver**: Upon recommendation of the MS thesis defense committee, an MSU/ECE MS thesis and defense can be submitted in fulfillment of part B of the Exam.

4.5 **Repeats:** At the discretion of the Graduate Studies Committee, an individual may be permitted to repeat the examination once.

4.6 **Appeals:** A student may review the graded Ph.D. qualifying examination by contacting the department's Graduate Coordinator. If after reviewing the exam, a student believes that an appeal on the exam outcome is warranted, such an appeal must be made in writing and directed to the department Chairperson. The written appeal must contain explicit reasons for requesting that the review be conducted. The appeal must be filed within two weeks from the date the student is notified of the Ph.D. qualifying examination results.

Topic Content of the Subject Areas for Part A of the Ph.D. Qualifying Examination

(Refer to the current edition of typical textbooks)

Circuit Fundamentals:

Fundamental laws and theorems associated with electric circuits, including Kirchhoff's current law and Kirchhoff's voltage law, power balance, Thevenin's theorom and Norton's theorom; circuit analysis methods and techniques, including node-voltage analysis, mesh-current analysis, and superposition; two-port networks and transfer functions; DC analysis; AC analysis including sinusoidal steady state phasors, s-domain representation including high-pass, low-pass, and band-pass filters; transient analysis including first-order and second-order circuits; current-voltage characteristics of elements including independent and dependent sources, resistors, capacitors, inductors, transistors, and operational amplifiers; analysis of circuits consisting of interconnections of such devices.

Typical Textbooks:

- Thomas and Rosa, The Analysis and Design of Linear Circuits, Wiley.
- Sadiku, Fundamentals of Electric Circuits, McGraw Hill.

Digital Logic Fundamentals:

Boolean algebra; Boolean minimization using Karnaugh maps; fundamental logic gates; combinational logic design; operation and structure of standard logic components (e.g., decoders, encoders, multiplexers, registers, counters, binary adders); programmable logic devices (PLAs);

sequential system fundamentals and state machines; synthesis of synchronous sequential circuits; arithmetic operations and circuits (addition, subtraction); memory elements and systems (ROM, RAM).

Typical Textbooks:
- Donaldson, Marcouitz, and Rizzoni, Digital Logic Fundamentals, McGraw Hill Primis.
- Mano and Kime, Logic and Computer Design Fundamentals, Prentice Hall.

Computers:

Microprocessor organization; microcontroller peripherals (e.g., parallel and serial I/O, interrupts, and timers); high-level and assembly language programming of microprocessors and digital signal processors; electronic design hierarchy and role of methodology; structural and behavioral modeling; transistor-level design of static CMOS combinational logic gates; DC and transient analysis of digital integrated circuits; physical design of CMOS logic gates and VLSI systems; FPGA/CPLD structures and operation; VHDL logic implementation; logic timing analysis.

Typical Textbooks:
- Miller, Microcomputer Engineering, Prentice Hall.
- Uyemura, Introduction to VLSI Circuits & Systems, John Wiley.
- Baker, Li, and Boyce, CMOS Circuit Design, Layout, and Simulation, IEEE Press.
- Roth, Digital Systems Design Using VHDL, ITP/PWS.

Control:

Mathematical models of systems; feedback control system characteristics and performance; sensitivity; time and frequency responses; Laplace transform analysis of time-invariant systems; stability; root locus method; Nyquist criterion and Bode plots; design and compensation.

Typical Textbooks:
- R.C. Dorf and R.H. Bishop, Modern Control Systems, Prentice Hall.
- N.S. Nise, Control Systems Engineering, Wiley.
- G.F. Franklin, J.D. Powell, and A. Emami-Naeini, Feedback control of dynamic systems, Prentice Hall.

Electromagnetics:

Electrostatics; magnetostatics; solution to static field equations for simple source systems and geometries; Maxwell's equations and their application in simple systems; wave equations for electric and magnetic fields; plane EM waves; pulse transmission lines with arbitrary termination; sinusoidal steady-state transmission lines; impedance transformation and the Smith chart; electromagnetic radiation, radiation from linear antennas.

Typical Textbooks:
- D. Cheng, Field and Wave Electromagnetics, Addison Wesley.
- N. N. Rao, Elements of Engineering Electromagnetics, Prentice Hall.
- U. Inan and A. Inan, Engineering Electromagnetics, Addison Wesley.

Electronic Devices:

Semiconductor basics: semiconductors and insulators; energy bands; charge carrier densities; conductivity; equilibrium properties; non-equilibrium properties and charge carrier transport; optoelectronic materials/structures. Diode basics: p-n and metal semiconductor junctions; biasing and switching behavior. Transistor basics: Bipolar junction transistors; MOSFETs; CMOS; biasing of transistors; equivalent circuits of transistors.

Typical Textbooks:
- B.G. Streetman, Solid State Electronic Devices, Prentice Hall (Recommended).
- R.E. Hummel, Electronic Properties of Materials, Springer.
- S.O. Kasap, Principles of Electronic Materials and Devices, McGraw Hill.
- D.A. Neamen, Semiconductor Physics and Devices: Basic Principles, McGraw Hill.

Signal Processing & Communication:

Analog and discrete signal models; sampling theory; linear time-invariant system analysis in the time domain; impulse response and convolution; Laplace transform and its use in analyzing LTI systems; Fourier series; Fourier transform and frequency response; discrete-time Fourier transform; z-transform and its use in analyzing discrete-time systems; amplitude and frequency modulation; basic probability, random variables, expected value, variance, covariance, some basic probability density functions.

Typical Textbooks:
- A. Oppenheim and A. Willsky , Signals and Systems, Prentice Hall
- A. Ambardar, Analog and Digital Signal Processing, Brooks/Cole.
- R. Ziemer and W. Tranter, Principles of Communications: systems, modulation, and noise, Wiley.

Power Systems:

Per unit system; delta and wye connections; single and three phase power; induction and synchronous machine models; operation and application of motors and generators, single and three phase transformer models; single and three phase uncontrolled and controlled rectifiers; single and three phase inverters; choppers; dc to dc converters; variable voltage and frequency drives; losses and efficiency; load flow input and output, symmetrical components.

Typical Textbooks
- D. Glover and M. Sarma; Power System Analysis and Design, Brooks/Cole.
- A.E. Fitzgerald,C. Kingsley, and S. Umans Electric Machinery, McGraw Hill.
- M.H Rahsid; Power Electronics: Circuits, Devices, and Applications, Prentice Hall

5. **Comprehensive Examinations**

5.1 **Objective:** The intent of the Ph.D. comprehensive examinations is (a) to identify the student's proposed areas of doctoral research; (b) to assess the adequacy of the student's general preparation for the proposed research area and related fields and possibly recommend areas for additional study; and (c) to review and evaluate the content and style of the thesis proposal and the student's ability to present the ideas orally.

5.2 **Schedule:** When the prescribed course work is substantially complete as defined by the Guidance Committee, the doctoral student is eligible to take the comprehensive examinations. There must be at least a six-month period between the date when the comprehensive examinations have been successfully completed and the final thesis defense.

5.3 **Format:** A doctoral student's comprehensive examinations decompose into several distinct components:

a. A written thesis proposal that is prepared by the student and presented to the Guidance Committee for review and evaluation.

b. An oral presentation of the thesis proposal, which occurs at least two weeks after the written thesis proposal is submitted to the Guidance Committee.

c. An oral and/or written examination(s) to access the student's preparation in the major and related field(s) of study for conducting the proposed research.

The Guidance Committee will decide whether or not this third portion of the comprehensive examinations will be written or oral and whether or not it will be conducted before, after, or at the same time as the oral presentation of the thesis proposal. Passing the comprehensive examinations shall require:

a. Satisfactory performance on the oral thesis proposal presentation.

b. Satisfactory performance on the formal examination.

c. A satisfactory written thesis proposal, a copy of which will be placed in the student's file.

5.4 **Evaluation Criteria:** The Committee will consider all of the information available to it, including an interview with the student to clarify unresolved issues, and render one of the following decisions:

a. The student passes the exams and is encouraged to finish all remaining requirements at the earliest possible time.

b. The student passes the exams and, except for identified deficiencies for which the Committee will prescribe a remedy, the student is encouraged to finish all remaining requirements at the earliest possible time.

c. The student fails the exams but is given permission to repeat a portion or all of them after certain conditions are met.

d. The student fails the exams and is asked to withdraw from the program at the end of the term.

Passing the comprehensive examinations requires approval of at least two thirds of the students guidance committee.

5.5 **Appeals:** A student may appeal the Guidance Committee's decision. Such an appeal must be made in writing and directed to the department Chairperson. The written appeal must contain explicit reasons for requesting that the review be conducted. The appeal must be filed within two weeks from the date the student is notified of the Guidance Committee's decision.

6. **Departmental Thesis Distribution**

A hard bound copy of the thesis is to be provided to the ECE Department, as well as a hard bound copy to the major professor. See also the graduate school requirements.

7. **General Requirements**

The college and university Ph.D. Program Regulations address all of the additional requirements for the Ph.D. degree. These include time limitations, grade-point average for graduation, grade-point calculation, acceptable grades, limitations on deferred grades, probation status, retention in program, examinations, evaluation, and thesis requirements. Students should consult the appropriate college and university documents for details.

TUITION, FEES, AND FINANCIAL AID

INTRODUCTION

This section provides electrical and computer engineering graduate students — and prospective graduate students — with information regarding tuition and fees, as well as financial aid opportunities available to students at Michigan State University. Financial aid for graduate students takes different forms. An individual financial aid package might include one or more of the following: a fellowship, a research assistantship, a teaching assistantship, a work-study assistantship, and a loan. Specific awards change with time to reflect changes in tuition, fees, and the general cost of living.

The Department of Electrical and Computer Engineering has a number of fellowships and assistantships available for qualified graduate students. Applicants for admission into either the M.S. or Ph.D. programs in electrical and computer engineering need only indicate their desire to be considered for financial aid on their application for admission. Students already in the graduate program should write directly to the department's Graduate Coordinator to apply for financial aid.

FINANCIAL AID OVERVIEW

Sources of financial aid include the University itself, the College of Engineering, the Department of Electrical and Computer Engineering, and off-campus organizations in both the public and private sector. Qualifications for receiving specific types of aid vary depending upon the funding source. And some financial aid packages place certain restrictions/responsibilities upon the recipient. For example, a one-half time graduate assistantship would pay the recipient a stipend of approximately $7,070 per semester for the 2001-2002 academic year; however, this stipend would require the recipient to perform up to twenty (20) hours per week of duties in service on the average to the University during the semester.

Some students receive financial-aid offers from more than one source. It is the Department's policy that the maximum amount of financial aid per semester — for funds administered by the University — shall not exceed the stipend equivalent to a one-half time assistantship, plus a complete waiver of all applicable tuition and fees.

CRITERIA FOR CONTINUED SUPPORT

Many financial-aid packages require that the student make satisfactory progress toward completing a degree of study. The Department's criteria for satisfactory academic progress includes: course credits completed per semester, the nature of these courses, the grades received, successful completion of required qualifying/certifying examinations, and progress in completing M.S. or Ph.D. dissertation research. In addition to satisfactory progress toward completing the degree, continuation of graduate support would depend upon the following: the recipient has performed the assigned duties satisfactorily; past level of support and total number of semesters of support; the availability of funds to continue the current level of financial assistance; the needs of the Department for the particular services for which the recipient is qualified to perform. When resources for financial aid are limited and the demand of aid exceeds the amount of funds available, continuation of financial aid for an individual will depend upon merit relative to others requesting aid and the needs of the Department to fulfill its overall mission of teaching, research and outreach. However, individual financial-aid packages may also be *upgraded* based upon a student's needs and interests, the student's academic progress, the Department's needs, and the availability of funds.

FEES AND RATES

TABLE I provides information regarding the fees and rates associated with enrolling in a graduate program administered by the College of Engineering at Michigan State University. The University reserves the right to make changes in the types, structure, and rates for fees and tuition. The fees and rates illustrated are current estimates and are based upon the semester system. These fees and rates are likely to increase each academic year. In the recent past, they have typically risen between five and ten percent per calendar year. For current information, see the "Tuition Fees, and Housing Calculator" at www.ctlr.msu.edu/studentrec/BU01.ASP.

The payment schedule provided indicates the estimated fees and rates assuming no financial aid. Many graduate students come to the University with financial aid; others obtain financial aid after a couple of semesters. A variety of financial aid packages are available to qualified students. More information is available about these opportunities by contacting the department.

The following examples illustrate the use of the calculator for determining the estimated per semester costs for the 2003-2004 academic year for tuition and fees only.

EXAMPLE 1 — A Michigan resident enrolling for nine credits would pay $3,360.00.

EXAMPLE 2 — An Out-of-State domestic resident enrolling for nine credits would pay $6,045.00. There is an additional International student registration fee of $25.

INSTRUCTIONS FOR APPLYING TO GRADUATE SCHOOL
for programs in the Department of Electrical and Computer Engineering
Michigan State University

Please go to www.egr.msu.edu/ece/students/apply1.php

Deadlines for graduate applications are as follows:

For admission in Fall Semester, applications must be received in complete form by January 15th of the preceding Spring term. For admission in Spring Semester, applications must be received in complete form by September 15th of the preceding Fall term.

Application Procedure for Graduate Studies in Electrical Engineering and the Ph.D. in Electrical Engineering:

Applicants should submit a completed application form on-line at MSU Graduate Admissions along with an application fee of $40. On-line applications are required except for those international students living in areas where internet access presents a very serious logistics problem. In that case, please send a request for a mail-in application. However, be advised that a mail-in application may result in a delay in consideration of the application which may have an impact on funding. The fee for a paper application is $45. The on-line application goes directly to the MSU Graduate School and is subsequently forwarded by the Graduate School to the Electrical and Computer Engineering Department. Please note that all applicants must submit a Personal Statement with the on-line application explaining your reasons for seeking graduate program enrollment and your career objectives.

In addition to submitting the application, the following 5 items must be submitted to the address listed below. *NOTE: If a paper application is used instead of an on-line application it must also go to this address below along with the fee.

Department of
Electrical & Computer Engineering
Attn: ECE Graduate Application Processing
2120 Engineering Building
Michigan State University
East Lansing, MI 48824-1226

1. Three Recommendation Forms must be completed by instructors or supervisors familiar with the applicants work. The e-mail address of the recommender must be provided on the form. Please provide a copy of the recommendation form to the recommender. For applicants from international schools, this form must be accompanied by letters of recommendation on official stationery from the recommender's institution.

2. A Graduate Admissions, Recruitment, and Financial Aid Information Sheet must also be filled out and submitted. (Note that this is an on-line form that is transmitted to the Graduate Admissions Secretary when submitted.)

3. Two official copies of transcripts from all previous universities attended.

4. Graduate Record Examination (GRE) aptitude scores are required for all International Applicants and for all other applicants with an undergraduate degree from an international school. The GRE is recommended for all other applicants. GRE test scores must be provided to us directly by the Educational Testing Service.

5. TOEFL Scores are required for all international applicants who are on an F-1 visa from a non-English speaking country. TOEFL test scores must be provided to us directly by the Educational Testing Service.

Note that items 1 through 5 above, along with the application form and the application fee, **are required** for a complete application to be considered for admissions. We do not waive these requirements, nor can the application fee be waived.

LETTER OF RECOMMENDATION

Applicant Name:____
Last First Middle

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
MICHIGAN STATE UNIVERSITY

To Applicant:

The Family Education and Privacy Act of 1974 gives students the right to inspect letters of recommendation written in support of applications for admission or fellowship. This law also permits students to waive that right if they so choose, although such a waiver cannot be a condition of admission or award. If you wish to waive your right to examine this letter of recommendation please sign the waiver below.

The following signed statement indicates the wish of the applicant regarding this recommendation.

I do waive ______ I do not waive ______ my right of access to the information in this recommendation

Signed____Date_______________________

To Recommender:

A. Please rate this applicant in overall promise for graduate work.

BELOW AVERAGE	AVERAGE	SOMEWHAT ABOVE AVERAGE	GOOD	EXCELLENT	OUTSTANDING	TRULY EXCEPTIONAL	INADEQUATE OPPORTUNITY TO OBSERVE
LOWEST 40	MIDDLE 20	NEXT 15	NEXT HIGHEST 15	HIGHEST 10			

B. The applicant's actual (if available) or approximate rank in his/her class is ________ out of ________ students.

C. How long have you known the applicant and in what capacity?

D. Please write additional comments about the applicant's capacity for serious scholarship and research.
(Use the back of this form if necessary.)

Signature____ Date __________________________

Name (print)____ Position__________________________

Institution____Email____________________________

Address ____ Zip________________

Return to:
Dept. of Electrical & Computer Engineering
Attn: ECE Graduate Application Processing
Michigan State University
2120 Engineering Building
East Lansing, MI 48824-1226