Erik Jonsson School of Engineering & Computer Science

Department of Electrical and Computer Engineering

Objectives

The program leading to the MSEE degree provides intensive preparation for professional practice in a broad spectrum of high-technology areas of electrical engineering. It is designed to serve the needs of engineers who wish to continue their education. Courses are offered at a time and location convenient for the student who is employed on a full-time basis.

The objective of the doctoral program in electrical engineering is to prepare individuals to perform original, leading edge research in the broad areas of communications and signal processing; mixed-signal IC design; digital systems; power electronics; microelectronics and nanoelectronics, optics and photonics; optical communication devices and systems; power electronics and energy systems, and wireless communications. Because of our strong collaborative programs with Dallas-area high-technology companies, special emphasis is placed on preparation for research and development positions in these high-technology industries.

Facilities

The Erik Jonsson School of Engineering and Computer Science has developed a state-of-the-art information infrastructure consisting of a wireless network in all buildings and an extensive fiber-optic and copper Ethernet. Through the Texas Higher Education Network, students and faculty have direct access to most major national and international networks. UT Dallas has an Internet 2 connection. In addition, many personal computers and UNIX workstations are available for student use.

The Engineering and Computer Science Building and the new Natural Science and Engineering Research Laboratory provide extensive facilities for research in microelectronics, telecommunications, and computer science. A Class 10000 microelectronics clean room facility, including e-beam lithography, sputter deposition, PECVD, LPCVD, etch, ash and evaporation, is available for student projects and research. The Plasma Applications and Science Laboratories have state-of-the-art facilities for mass spectrometry, microwave interferometry, optical spectroscopy, optical detection, in situ ellipsometry and FTIR spectroscopy. In addition, a modified Gaseous Electronics Conference Reference Reactor has been installed for plasma processing and particulate generation studies. Research in characterization and fabrication of nanoscale materials and devices is performed in the Nanoelectronics Laboratory. The Optical Communications Laboratory includes attenuators, optical power meters, lasers, APD/p-i-n photodetectors, optical tables, and couplers and is available to support system level research in optical communications. Tissue optics research is also supported in this laboratory. The Photonic Testbed Laboratory supports research in photonics and optical communications with current-generation optical networking test equipment. The Electronic Materials Processing Laboratory has extensive facilities for fabricating and characterizing semiconductor and optical devices. The Photonic Devices and Systems Laboratory houses graduate research projects centered on optical instrumentation and photonic integrated circuits. The Renewable Energy and Vehicular Technology Laboratory (REVT-Lab) is equipped with
various sources of renewable energy such as wind and solar, a micro-grid formed by a network of multi-port power electronic converters, a stationary plug in hybrid vehicle testbed, a stationary DFIG-based wind energy emulator, a series of adjustable speed motor drive technologies including PMSM, SRM and induction motor drives. All of the testbeds are equipped with digital control, state-of-the-art measurement and protection devices. REVT laboratory is also equipped with a cold plasma chamber for hydrogen harvesting and battery testing facilities. The main focus of the REVT Lab is to improve reliability and security of the power electronic-driven technologies as applied to utility and vehicular industries.

The Power Electronics and Drives Laboratory (PEDL) is focused on advanced power electronics, electric drives systems, and energy management technologies for efficiency improvements in industrial, transportation, and renewable energy applications. The facilities include a real-time simulation lab and a hardware experimental lab. The simulation lab is an innovative digital signal processor based power electronics and motor drives hand-on teaching platform, tailored for graduate and undergraduate students as well as for practicing engineers. This new platform enables students to rapidly and efficiently learn to program DSP and configure the peripherals for real-time applications and control/manage the power digitally. The hardware experimental lab is equipped with state-of-the-art power testing equipment, dynamometers, prototype PWB manufacturing equipment, an environmental test chamber, and a mechanical shop. The lab is equipped with state-of-the-art tools and instrumentation necessary for development of power electronic circuits and systems for high power applications.

The Texas Analog Center of Excellence (TxACE) at The University of Texas at Dallas (UT Dallas) has the mission of leading the country in analog research and education. TxACE research seeks to create fundamental analog, mixed signal and RF design innovations in integrated circuits and systems that improve energy efficiency, healthcare, and public safety and security. The center is supported by Semiconductor Research Corporation, Texas Emerging Technology Fund, Texas Instruments Inc., the UT System, and UT Dallas. TxACE is the largest analog technology center in the world on the basis of funding and the number of principal investigators. The center funds ~70 directed research projects led by ~65 principal and co-principal investigators from 31 academic institutions including three international institutions.

The Multimedia Communications Laboratory has a dedicated network of PC's, Linux stations, and multi-processor, high performance workstations for analysis, design and simulation of image and video processing systems. The Signal and Image Processing (SIP) Laboratory is equipped with DSP, FPGA, GPU, and smartphone implementation hardware platforms where experimentations are conducted related to the following two major research thrusts: (i) development and real-time execution of camera image pipeline solutions, and (ii) biomedical signal and image processing. The Statistical Signal Processing Laboratory is dedicated to research in statistical and acoustic signal processing for biomedical and non-biomedical applications. It is equipped with high-performance computers and powerful textual and graphical software platforms to analyze advanced signal processing methods, develop new algorithms, and perform system designs and simulations. The Acoustic Research Laboratory provides number of test-beds and associated equipment for signal measurements, system modeling, real-time implementation and testing of algorithms related to audio/ acoustic/speech signal processing applications such as active noise control, speech enhancement, dereverberation, echo cancellation, sensor arrays, psychoacoustic signal processing, etc.

The Center for Robust Speech Systems (CRSS) is focused on a wide range of research in the area of speech signal processing, speech and speaker recognition, speech/language
technology, and multi-modal signal processing involving facial/speech modalities. CRSS is affiliated with HLTRI in the Erik Jonsson School, and collaborates extensively with faculty and programs across UT Dallas on speech and language research. CRSS supports an extensive network of workstations, as well as a High-Performance Compute Cluster with over 30TB of disk space and 420 CPU ROCS multi-processor cluster. The center also is equipped with several Texas Instruments processors for real-time processing of speech signals, and two ASHA certified sound booths for perceptual/listening based studies and for speech data collection. CRSS supports mobile speech interactive systems through the UT Drive program for in-vehicle driver-behavior systems, and multi-modal based interaction systems via image-video-speech research.

The Sensing, Robotics, Vision, Control and Estimation (SeRViCE) Lab focuses on topics of control and estimation with applications in robotics, autonomous vehicles and sensor management. Primary expertise is in vision-based control and estimation and nonlinear control, that is, using cameras as the primary sensor to control robots or other complex systems. Robotics resources in the lab currently include two Pioneer 3-DX mobile robots from Mobile Robots Inc. and a Staubli TX90 robot manipulator, with six degrees of freedom, 7kg nominal payload and capable of torque level control. Camera resources include multiple web cameras, three high-quality, firewire, color, digital video cameras, and an 18Mp digital SLR camera. The SeRViCE Lab also features general support equipment, including desktop and mobile work stations DLP projectors, power tools, hand tools, oscilloscopes, and other electronic measurement equipment.

The Laboratory for Autonomous Robotics and Systems (LARS) focuses on the development of novel control theory to support autonomous and teleoperation of general robotic systems. Active research projects include: (a) human-in-the-loop multi-robot telemanipulation, (b) autonomous networked robotics, and (c) control of bipedal walking robots. The LARS is equipped with high speed high resolution 8-camera Vicon motion capture system for general purpose motion tracking. The LARS possesses various mobile robots to supported multi-robot research, including six gumstix controlled iRobot Creates and a Quanser QBall quadrotor UAV. The LARS also possesses various force feedback user interface devices, including Logitech force feedback joystick and driving wheel, and Novint Falcon, a 3-translational degree-of-freedom Delta-structure desktop haptic device.

The Broadband Communication Laboratory has design and modeling tools for fiber and wireless transmission systems and networks, and all-optical packet routing and switching. The Advanced Communications Technologies (ACT) Laboratory provides a design and evaluation environment for the study of telecommunication systems and wireless and optical networks. ACT has facilities for designing network hardware, software, components, and applications.

The Wireless Information Systems (WISLAB) and Antenna Measurement Laboratories have wireless experimental equipment with a unique multiple antenna testbed to integrate and to demonstrate radio functions (i.e. WiFi and WiMAX) under different frequency usage characteristics. With the aid of the Antenna Measurement Lab located in the Waterview Science and Technology Center (WSTC), the researchers can design, build, and test many types of antennas.

The Quality of Life Technology Laboratory is a multidisciplinary engineering education, research and developmental laboratory aimed at improving Quality of Life of people through technological advancements, innovations, and intelligent system designs. It has design, modeling and simulation tools for medical devices and systems.

The Integrated Design, Engineering, and Algorithmics (IDEA) Lab promotes education and research in the following areas: digital, analog and mixed-signal integrated circuit design
and test; power electronics and energy systems; embedded and IoT systems; DSP and communication circuits and systems; rapid-prototyping; CAD algorithms. This lab is equipped with a network of workstations, personal computers, FPGA development systems, prototyping equipment, and a wide spectrum of state-of-the-art commercial and academic design tools to support graduate research.

In addition to the facilities on campus, cooperative arrangements have been established with many local industries to make their facilities available to UT Dallas graduate engineering students.

Master of Science in Electrical Engineering

33 semester credit hours minimum

Department Faculty


Professors Emeritus: Louis R. Hunt, William J. Pervin, Don Shaw

Research Professor: Hisashi (Sam) Shichijo

Associate Professors: Carlos A. Busso-Recabarren, Rashaunda Henderson, Wenchuang (Walter) Hu, Siavash Pourkamali, Chin-Tuan Tan

Clinical Associate Professor: Nicholas Gans

Assistant Professors: Bilal Akin, Joseph Callenes-Sloan, Benjamin Carrion Schafer, Joseph Friedman, Ping Gu, Jeyavijayan Rajendran, Chadwin D. Young

Senior Lecturers: Peter A. Blakney, Diana Cogan, Paul Deignan, James Florence, Matthew Heins, Jung Lee, Randall E. Lehmann, Ricardo E. Saad, William (Bill) Swartz, Marco Tacca

UT Dallas Affiliated Faculty: Leonidas Bleris, Yves J. Chabal, Wonjae Choi, Bruce E. Gnade, Matthew J. Goeckner, Robert D. Gregg, Zygmunst Haas, Kenneth Hoyt, Jiyoung Kim, Moon J. Kim, David J. Lary, Yang Liu, Ann Majewicz, S.O. Reza Moheimani, Wooram Park, Mario A. Rotea, Mathukumalli Vidyasagar, Amy V. Walker, Robert M. Wallace, Steve Yurkovich, Jie Zhang

Admission Requirements

The University's general admission requirements are discussed on the [Graduate Admission page](https://catalog.utdallas.edu/2016/graduate/admission). A student lacking undergraduate prerequisites for graduate courses in electrical engineering must complete these prerequisites or receive approval from the graduate advisor and the course instructor. A diagnostic exam may be required. Specific admission requirements follow. The student entering the MSEE program should meet the following guidelines:

- An undergraduate preparation equivalent to a baccalaureate in electrical engineering from an accredited engineering program.
- A grade point average in upper-division quantitative coursework of 3.0 or better on a 4.0 point scale, and
• GRE revised scores of 154, 156, and 4 for the verbal, quantitative, and analytical writing components, respectively, are advisable based on our experience with student success in the program.

Applicants must submit three letters of recommendation from individuals who are able to judge the candidate's probability of success in pursuing a program of study leading to the master's degree. Applicants must also submit an essay outlining the candidate's background, education, and professional goals. Students from other engineering disciplines or from other science and math areas may be considered for admission to the program; however, some additional coursework may be necessary before starting the master's program.

Degree Requirements

The University's general degree requirements are discussed on the Graduate Policies and Procedures page (catalog.utdallas.edu/2016/graduate/policies/policy). The MSEE requires a minimum of 33 semester credit hours.

All students must have an academic advisor and an approved degree plan. These are based upon the student's choice of concentration (Biomedical Applications of Electrical Engineering; Circuits and Systems; Communications; Control Systems; Digital Systems; Photonic Devices and Systems; Power Electronics and Energy Systems, RF and Microwave Engineering, Signal Processing; Solid State Devices and Micro Systems Fabrication). Courses taken without advisor approval will not count toward the 33 semester credit hour requirement. Successful completion of the approved course of studies leads to the MSEE degree.

The MSEE program has both a thesis and a non-thesis option. All part-time MSEE students will be assigned initially to the non-thesis option. Those wishing to elect the thesis option may do so by obtaining the approval of a faculty thesis supervisor. With the prior approval of an academic advisor, non-thesis students may count no more than 3 semester credit hours of research or individual instruction courses towards the 33 semester credit hour degree requirement.

All full-time, supported students are required to participate in the thesis option. The thesis option requires nine semester credit hours of research (of which three must be thesis semester credit hours), a written thesis submitted to the graduate school, and a formal public defense of the thesis. The supervising committee administers this defense and is chosen in consultation with the student's thesis advisor prior to enrolling for thesis credit. Research and thesis semester credit hours cannot be counted in an MSEE degree plan unless a thesis is written and successfully defended.

Concentrations

One of the nine concentrations listed below, subject to approval by a graduate advisor, must be used to fulfill the requirements of the MSEE program. Students must achieve an overall GPA (grade point average) of 3.0 or better, a GPA of 3.0 or better in their core MSEE classes, and a grade of B- or better in all their core MSEE classes in order to satisfy their degree requirements. One 5000 level electrical engineering course can be counted towards the graduate semester credit hours.

Biomedical Applications of Electrical Engineering

This curriculum provides a graduate-level introduction to advanced methods and biomedical applications of electrical engineering.
Each student electing this concentration must take 15 semester credit hours:

- **EEBM 6373** Anatomy and Human Physiology for Engineers
- **EEBM 6374** Genes, Proteins and Cell Biology for Engineers
- **EEBM 6376** Lecture Course in Biomedical Applications of Electrical Engineering

and two core courses from any one other concentration.

Approved electives must be taken to make a total of 33 semester credit hours. Depending on the specific orientation of the course program it can be very beneficial to the student to take courses from other departments (e.g. Biology, Chemistry, Brain and Behavioral Sciences, Computer Science-Bioinformatics). Typically, not more than three approved courses can be taken outside the electrical engineering (EE) department. Additional courses can be taken only with the explicit approval by the department head. It is highly recommended that students take an independent study course with an EE faculty member that will be counted as one of the EE electives. The independent study course is intended to gear the coursework towards one of the following research areas in the department: biosensors, biomedical signal processing, bioinstrumentation, medical imaging, biomaterials, and bio-applications in RF.

Circuits and Systems

The courses in this curriculum emphasize the design and test of circuits and systems, and the analysis and modeling of integrated circuits. Each student electing this concentration must take five required courses (15 semester credit hours).

**Two of the courses are:**

- **EECT 6325** VLSI Design
- **EECT 6326** Analog Integrated Circuit Design

**The remaining three courses must be selected from:**

- **EECT 6378** Power Management Circuits
- **EECT 6379** Energy Harvesting, Storage, and Powering for Microsystems
- **EECT 7325** Advanced VLSI Design
- **EECT 7326** Advanced Analog Integrated Circuit Design
- **EECT 7327** Data Converters
- **EEDG 6301** Advanced Digital Logic
- **EEDG 6303** Testing and Testable Design
- **EEDG 6306** Application Specific Integrated Circuit Design
- **EEDG 6375** Design Automation of VLSI Systems
- **EERF 6330** RF Integrated Circuit Design

Approved electives must be taken to make a total of 33 semester credit hours.
Communications
This curriculum emphasizes the application and theory of all phases of modern communications. Each student electing this concentration must take four required courses (12 semester credit hours).

Two of the courses are:
- EESC 6349 Random Processes
- EESC 6352 Digital Communication Systems

The remaining two must be selected from:
- EEOP 6310 Optical Communication Systems
- EERF 5305 Radio Frequency Engineering
- EESC 6340 Introduction to Telecommunications Networks
- EESC 6341 Information Theory I
- EESC 6343 Detection and Estimation Theory
- EESC 6344 Coding Theory
- EESC 6353 Broadband Digital Communication
- EESC 6360 Digital Signal Processing I
- EESC 6390 Introduction to Wireless Communication Systems

Approved electives must be taken to make a total of 33 semester credit hours.

Control Systems
This curriculum emphasizes methods to predict, estimate, and regulate the behavior of electrical, mechanical, or other systems including robotics. Each student electing this concentration must take four required courses (12 semester credit hours).

Two of the courses are:
- EECS 6331 Linear Systems
- EESC 6349 Random Processes

The remaining two must be selected from:
- EECS 6336 Nonlinear Systems
- EEGR 6381 Computational Methods in Engineering
- EESC 6343 Detection and Estimation Theory
- EESC 6360 Digital Signal Processing I
- EESC 6364 Pattern Recognition
EESC 7V85 Special Topics in Signal Processing

Approved electives must be taken to make a total of 33 semester credit hours.

Digital Systems
The goal of the curriculum is to educate students about issues arising in the design and analysis of digital systems, an area relevant to a variety of high-technology industries. Because the emphasis is on systems, coursework focuses on three areas: hardware design, software design, and analysis and modeling. Each student electing this concentration must take four required courses (12 semester credit hours):

Two of the courses are:

- EEDG 6301 Advanced Digital Logic
- EEDG 6304 Computer Architecture

The remaining two must be selected from:

- EECT 6325 VLSI Design
- EEDG 6302 Microprocessor Systems
- EEDG 6345 Engineering of Packet-Switched Networks

Approved electives must be taken to make a total of 33 semester credit hours.

Photonic Devices and Systems
This curriculum is focused on the application and theory of modern optical devices, materials, and systems.

Each student electing this concentration must take four required courses (12 semester credit hours):

- EEGR 6316 Fields and Waves
- EEOP 6310 Optical Communication Systems
- EEOP 6311 Photonic Devices and Integration
- EEOP 6314 Principles of Fiber and Integrated Optics

Approved electives must be taken to make a total of 33 semester credit hours.

Power Electronics and Energy Systems
The goal of the curriculum is to prepare students to address growing needs in contemporary power electronics and energy related areas. The coursework focuses on fundamentals of power electronics, design and control of motor drives, power management, and energy systems.

Each student electing this concentration must take four required courses (12 semester credit hours):

Two of the courses are:
EEPE 6354 Power Electronics
EEPE 6356 Adjusted Speed Motor Drives

The remaining two must be selected from:
EECT 6378 Power Management Circuits
EECT 6379 Energy Harvesting, Storage and Powering for Microsystems
EEPE 6357 Control, Modeling and Simulation in Power Electronics
EEPE 6358 Electrification of Transportation
EEPE 6359 Renewable Energy Systems and Distributed Power Generation Systems
EEPE 7356 Computer Aided Design of Electric Machines
EEPE 7V91 Special Topics in Power Electronics

Approved electives must be taken to make a total of 33 semester credit hours.

RF and Microwave Engineering
This curriculum is focused on the application and theory of modern electronic devices, circuits, and systems in the radiofrequency and microwave regime. Each student electing this concentration must take the following four required courses (12 semester credit hours):

Four of the courses are:
EEGR 6316 Fields and Waves
EERF 6311 RF and Microwave Circuits
EERF 6355 RF and Microwave Amplifier Design
EERF 6395 RF and Microwave Systems Engineering

Approved electives must be taken to make a total of 33 semester credit hours.

Signal Processing
This curriculum emphasizes the application and theory of signal processing. Each student electing this concentration must take four required courses (12 semester credit hours).

Two of the courses are:
EESC 6349 Random Processes
EESC 6360 Digital Signal Processing I

The remaining two must be selected from:
EESC 6343 Detection and Estimation Theory
EESC 6350 Signal Theory
EESC 6361 Digital Signal Processing II
EESC 6362 Introduction to Speech Processing
EESC 6363 Digital Image Processing
EESC 6364 Pattern Recognition
EESC 6365 Adaptive Signal Processing
EESC 6366 Speech and Speaker Recognition
EESC 6367 Applied Digital Signal Processing
EESC 7V85 Special Topics in Signal Processing

Approved electives must be taken to make a total of 33 semester credit hours.

Solid State Devices and Micro Systems Fabrication

This concentration is focused on the fundamental principles, design, fabrication and analysis of solid-state devices and associated micro systems. Each student electing this concentration must take four required courses (12 semester credit hours).

Two of the courses are:

EEGR 6316 Fields and Waves
EEMF 6319 Quantum Physical Electronics

and at least two of the following four courses:

EEMF 6320 Fundamentals of Semiconductor Devices
EEMF 6321 Active Semiconductor Devices
EEMF 6322 Semiconductor Processing Technology
EEMF 6382 Introduction to MEMS

Approved electives must be taken to make a total of 33 semester credit hours.

Doctor of Philosophy in Electrical Engineering

75 semester credit hours minimum beyond the baccalaureate degree

Department Faculty


**Associate Professors:** Carlos A. Busso-Recabarren, Rashaunda Henderson, Wenchuang (Walter) Hu, Siavash Pourkamali, Chin-Tuan Tan
Assistant Professors: Bilal Akin, Joseph Callenes-Sloan, Benjamin Carrion Schafer, Joseph Friedman, Qing Gu, Jeyavijayan Rajendran, Chadwin D. Young
Clinical Associate Professor: Nicholas Gans
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Senior Lecturers: Peter A. Blakey, Diana Cogan, Paul Deignan, James Florence, Matthew Heins, Jung Lee, Randall E. Lehmann, Ricardo E. Saad, William (Bill) Swartz, Marco Tacca
Professors Emeritus: Louis R. Hunt, William J. Pervin, Don Shaw

Admission Requirements

The University's general admission requirements are discussed on the Graduate Admission page (catalog.utdallas.edu/2016/graduate/admission).
The PhD in Electrical Engineering is awarded primarily to acknowledge the student's success in an original research project, the description of which is a significant contribution to the literature of the discipline. Applicants for the doctoral program are therefore selected by the Electrical Engineering Program Graduate Committee on the basis of research aptitude, as well as academic record. Applications for the doctoral program are considered on an individual basis.
The following are guidelines for admission to the PhD program in Electrical Engineering:

- A master's degree in electrical engineering or a closely associated discipline from an institution of higher education in the U.S. or from an acceptable foreign university. Consideration will be given to highly qualified students wishing to pursue the doctorate without satisfying all of the requirements for a master's degree. A grade point average (GPA) in graduate coursework of 3.5 or better on a 4.0 point scale
- GRE revised scores of 154, 156, and 4 for the verbal, quantitative, and analytical writing components, respectively, are advisable based on our experience with student success in the program.

Applicants must submit three letters of recommendation on official school or business letterhead or the UT Dallas Letter of Recommendation Form from individuals who are familiar with the student's record and able to judge the candidate's probability of success in pursuing doctoral study in electrical engineering.
Applicants must also submit a narrative describing their motivation for doctoral study and how it relates to their professional goals.
For students who are interested in a PhD but are unable to attend school full-time, there is a part-time option. The guidelines for admission to the program and the degree requirements are the same as for full-time PhD students. All students must have an academic advisor and an approved plan of study.

Degree Requirements

The University's general degree requirements are discussed on the Graduate Policies and Procedures page (catalog.utdallas.edu/2016/graduate/policies/policy).
Each program for doctoral study is individually tailored to the student's background and research objectives by the student's supervisory committee. The program will require a minimum of 75 semester credit hours beyond the baccalaureate degree. These credits must include at least 30 semester credit hours of graduate level courses beyond the baccalaureate level in the major concentration. All PhD students must demonstrate competence in the master's level core courses in their research area. All students must have an academic advisor and an approved plan of study.
Also required are:
EE PhD qualifying exam (QE). The QE consists of two parts: background knowledge part (Part 1) and research capability part (Part 2). Passing of QE requires passing both parts in any order within 3 long semesters starting from the first semester of admission into the UTD EE Ph.D. program for students with MS degree and within 4 long semesters for students with BS degree. The QE application form for each part should be submitted to the EE Graduate Office by the Census Day of the full-term session of a long semester. Details of EE Ph.D. Qualifying Exam (QE) policy can be found on the EE department website. A comprehensive exam consisting of: a written dissertation proposal, a public seminar, and a private oral examination conducted by the PhD candidate’s supervising committee. At least half of the supervising committee must comprise of core EE faculty members and it must be chaired or co-chaired by an EE faculty member.

Completion of a major research project culminating in a dissertation demonstrating an original contribution to scientific knowledge and engineering practice. The dissertation will be defended publicly. The rules for this defense are specified by the Office of the Dean of Graduate Studies. Neither a foreign language nor a minor is required for the PhD. However, the student's supervisory committee may impose these or other requirements that it feels are necessary and appropriate to the student's degree program.

Research

The principal concentration areas for the MSEE program are: Biomedical Applications of Electrical Engineering; Circuits and Systems; Communications; Control Systems; Digital Systems; Photonic Devices and Systems; Power Electronics and Energy Systems, RF and Microwave Engineering; Signal Processing; Solid State Devices and Micro Systems Fabrication. Besides courses required for each concentration, a comprehensive set of electives is available in each area. Doctoral level research opportunities include: VLSI design and test, analog and mixed-signal circuits and systems, RF and microwave engineering, biomedical applications of electrical engineering, power electronics, renewable energy, motors and drives, vehicular technology, computer architecture, embedded systems, computer aided design (CAD), ASIC design methodologies, high speed system-on chip design and test, reconfigurable computing, network processor design, interconnection networks, nonlinear signal-processing, smart antennas and array processing, statistical and adaptive signal processing, multimedia signal processing, image processing, real-time imaging, medical image analysis, pattern recognition, speech processing and recognition, control theory, robotics, digital communications, modulation and coding, electromagnetic-wave propagation, diffractive structures, fiber and integrated photonics, nonlinear optics, optical transmission systems, all-optical networks, optical investigation of material properties (reflectometry and ellipsometry), optical instrumentation, lasers, quantum-well optical devices, theory and experiments in semiconductor-heterostructure devices, plasma deposition and etching, nanoelectronics, wireless communication, network protocols and evaluation, mobile computing and networking, and optical networking. Interdisciplinary Opportunities: Continuing with the established tradition of research at UT Dallas, the Electrical Engineering Program encourages students to interact with researchers in the strong basic sciences and mathematics. Cross disciplinary collaborations have been established with the Chemistry, Mathematics, and Physics programs of the School of Natural Sciences and with faculty in the School of Brain and Behavioral Science.