

# Department of Electrical Engineering

## Dr. T.S. Sudarshan, Chair

The National Research Council (NRC) ranks the University of South Carolina Electrical Engineering (EE) department

- 7<sup>th</sup> in program quality nationally  
[http://www.gs.howard.edu/NRC\\_2/elect%20eng%20s%203.pdf](http://www.gs.howard.edu/NRC_2/elect%20eng%20s%203.pdf)
- 6<sup>th</sup> in faculty research productivity nationally, and
- 1<sup>st</sup> in both program quality and faculty research productivity in the South.

These rankings are much higher than many top tier schools. The department offers B.S., M.S./M.E. and Ph.D. degrees in Electrical Engineering. As of fall 2010 the department has fifteen full-time faculty, an undergraduate enrollment of 164, a graduate enrollment of 94 that includes 20 in distance education (APOGEE) program, and 2009-10 annual research expenditures of about \$5.5 million dollars. The department has two IEEE Fellows, many internationally acclaimed professors, and several National Science Foundation Career award winners.

Faculty members publish on an average 32 refereed journal articles and 57 conference papers in a year. The department graduates on an average 38 B.S., 22 M.S./M.E. and 9 Ph.D. students per year. Most of our Master's and Ph.D. graduates work in the energy, telecom, computer, semiconductor, and defense industries and state and federal governments. The department boasts state of the art cleanroom fabrication and characterization facilities for microelectronics and nanoelectronics research. "Virtual TestBed," a real time naval ship power system simulation software, pioneered in the department is widely used by academia and industry for power systems research. The department has microwave wireless fabrication and characterization facilities to conduct research on novel antennas, computer signal integrity, and wireless sensors. The department's research activities are funded by the Office of Naval Research, the Army Research Office, DARPA, MDA, the National Science Foundation, and many other federal agencies and private organizations.

## Research and Enterprise

The EE Department's core research expertise is in energy, power systems and control; microelectronics, nanoelectronics and photovoltaics; and antennas, electromagnetics and signal integrity.

### 1. Power and Energy

The power and energy research group consists of **Dr. Roger Dougal** (Thomas Gregory Professor), **Charles Brice**, **Enrico Santi**, **Herbert L. Ginn III**, and **Yong-June Shin**. The group focuses on system level simulations of power systems, physics based semiconductor device modeling of power converters, joint time-frequency domain reflectometry for cable diagnostics, future fuel cells, and many other cutting edge power and energy related research topics.

The group's most notable activities include participation in a leading role in the Office of Naval Research (ONR) Electric Ship Research and Development Consortium (ESRDC) and in an NSF sponsored Industry/University Collaborative Research Center (IUCRC) on Grid-connected Advanced Power Electronics Research (GRAPE) Center with the University of Arkansas. Specific research activities include the following:



**Dr. Brice's** research area is electric power systems and rotating machines, including utility and industrial systems. He is currently researching two projects: Effects of power electronic drives and renewable energy sources on voltage stability of power systems, and advanced on-line diagnostics for steel-mill drives and motors.



**Dr. Dougal's** research encompasses power systems including new power sources, power system reliability, reconfigurability, and smart grid. He leads the ESRDC consortium at USC. The well known Virtual Test Bed (VTB) software developed under his guidance offers unique capabilities for collaborative design, virtual prototyping, and testing of multidisciplinary dynamic systems including power, control, and thermal systems. VTB addresses significant issues, such as direct code generation for system controllers, propagation effects of design or parameter uncertainties through non-linear systems, direct-to-hardware rapid prototyping methods, and distributed virtual laboratories using hardware-in-the-loop.



**Dr. Ginn's** research interests include power electronics applications in power systems as well as power phenomena, and compensation in power distribution systems. He has extensive experience in the design, operation and control of power electronic converters as well as both passive and active harmonic filters. His current research activities are focused on the control and coordination of power electronic converters in special case distribution systems such as self contained vehicular systems and microgrids.

**Dr. Santi's** research focuses on incorporating wide band-gap semiconductors, such as GaN devices into high-power wide-bandwidth power converters, design and rapid proto-



typing of controls for power electronic systems. His research also includes the development of new accurate physics-based circuit-oriented models of power semiconductor devices consisting of silicon and silicon carbide devices.



**Dr. Shin's** research is Power IT (Information Technology) characterized by applications of cutting-edge information technology such as signal processing and communication theory to the future electric power transmission and distribution systems, i.e., smart grid in order

to resolve power quality and reliability problems associated with renewable energy resources and condition based maintenance (CBM) of aircraft. One of his major research thrusts is on developing a new joint time-frequency domain reflectometry (JTFR) technique for diagnostics and prognostics of electric power infrastructure.

### 2. Microelectronics, Nanoelectronics and Photovoltaics

Currently there are seven faculty members in this research area: **Dr. Asif Khan** (Carolina Distinguished Professor), **Tangali Sudarshan** (Carolina Distinguished Professor and Chair), **Grigory Simin**, **Goutam Koley**, **Krishna Mandal**, and **MVS Chandrashekhar**. The research thrusts of these faculty include novel widebandgap semiconductor materials, photonic and microelectronic devices and circuits, nanoscale electronics, and photovoltaics. Some of the world class research activities that are ongoing and forthcoming in this group are given below.



**Dr. Chandrashekhar** works on advanced semiconductor materials and their application to clean-energy problems. In particular, he works with epitaxial graphene and its derivatives formed on SiC substrates, providing unprecedented versatility in a single electronic material platform than previously possible. He is interested in applications in emissions sensing, power electronics as well as the investigation of the fundamental physics in this novel materials system.



**Dr. Khan's** research is on novel wide bandgap semiconductor materials and devices for application in next generation compact water purification elements, miniature biosensors, high-power military radars, solid state lighting, and other military electronics systems.

The research team pushes the frontiers of aluminium gallium nitride (AlGaN) based ultraviolet optoelectronics such as deep UV light emitters using novel crystal growth and

micro-processing techniques. On the electronics side, his group is developing high power, high frequency, and high temperature transistor modules for next generation radars and power electronics. His group has pioneered a new insulating gate MOS Transistor which has become a robust building block for high temperature (300°C) high rf-power electronics. Based on the research his team has undertaken two successful companies have been created: Sensor Electric Technology and Nitek Inc.



**Dr. Koley's** Nanoscale Electronics and Sensors Laboratory (NESL) focuses on detection of chemicals and bio-molecules using resonant microcantilevers, which resemble tiny diving boards. The sensing is based on changes in electrical, mechanical, or chemical properties caused by adsorption of the target molecules. Investigations are also being carried out on nanostructures as resonating elements for detection of chemical and bio molecules, taking advantage of their unique physical properties. Another important focus of this group is nano-characterization and nanoelectronics including the development of special scanning probe modes for characterization of nanowires and nanoparticles.



**Dr. Mandal's** research interests are in the areas of third generation photovoltaic solar cells for sustainable energy including nanocrystalline dye-sensitized solar cells on lightweight flexible plastics and quantum dot solar cells. Mandal's group is also working on novel semiconductor materials and devices for direct read-out X-ray, gamma-ray and neutron detection systems for Homeland security, medical imaging, and THz applications. Students in this area will work on projects tackling the most challenging problems facing the world today - sustainable energy and counter terrorism measures.



**Dr. Simin's** group focuses on the development of novel high-power highspeed electronics using wide bandgap devices and integrated circuits (ICs). These novel building blocks for future electronics can operate at temperatures exceeding 300°C and handle power 10-100 times higher than traditional silicon or gallium arsenide devices. Transistors with operating voltages in excess of 1.5 kV have been recently demonstrated. Based on these achievements, devices and ICs for next generation of power converters are now being developed. The group is also working on microwave switches and other control devices utilizing wide bandgap materials and novel principles of signal injection/extraction.

**Dr. Sudarshan's** research team focuses on the development of high quality silicon carbide (SiC), a wide



bandgap semiconductor, for applications that require devices to operate at high temperatures and high power levels in automobiles, aircraft, and the power grid; and also in harsh environments including deep oil well exploration and nuclear reactors. The team's major research goals are to significantly improve SiC material quality of epitaxial films, study the electrical properties of individual defects and their influence on short term and long term electrical characteristics of diodes (Schottky barrier and p-i-n) and bipolar junction transistor (BJT) structures, and develop advanced processes to achieve high voltage breakdown of devices, all of which are key to the development of successful commercial SiC technology.

### 3. Antennas, Electromagnetics, and Signal Integrity

This research group consists of **Drs. Paul G. Huray, Mohammod Ali, Yinchao Chen, and Guoan Wang.** This group focuses on the present day challenges of communications technology that stems from the rapid miniaturization of circuits, components, and antennas. These include but are not limited to antennas and microwave circuit design, numerical electromagnetics, computer signal integrity, and mobile multi-media technology. The team's research is directed towards national defense, commercial wireless, automobile, and medical applications. The exciting research activities that are ongoing and forthcoming in this group are given below.



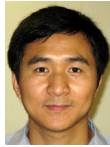
**Dr. Ali's** research interests include miniaturized packaged (embedded) antennas, meta-materials and their antenna applications, distributed wireless sensors, and portable/wearable antennas and their interactions with humans. These include platform integrated antennas for smartphones, conformal load bearing antennas, and reconfigurable antennas for advanced structures. His team's focus is to perform fundamental research to improve antenna bandwidth, pattern coverage, and efficiency improvement and thereby significantly reduce the platform dependence of antenna design. His second major research focus is on wireless sensors to monitor infrastructure, such as bridges, buildings, pipelines, and power system transmission and distribution lines.



**Dr. Chen's** current research interests include signal integrity for high speed circuits; computational electromagnetics; RF, millimeter-wave, and microwave integrated circuits; wireless communication devices; electronic packaging modeling for VLSI devices; and antenna and scattering applications.



**Dr. Huray's** research area is Signal Integrity which ensures that electronic circuits interconnect reliably without unintended variations in signal quality. The interaction of signal fields with atoms, molecules, impurities, periodic fiberglass weave, and rough conductor surfaces attenuate and disperse signals. Those effects create barriers to reliable high speed information transfers that will occur in future generations of electronic systems. He and his graduate students concentrate on the theory of electromagnetic field propagation described by Maxwell's equations and use measurement and simulation of real-world interconnect models to confirm the theory.



**Dr. Wang's** research interests include smart RF passives/systems such as MEMS based RF components/systems and on-chip tunable RF components/systems, MEMS/NEMS and their RF and Bio-medical applications, novel materials and their mmwave applications, and 3D IC and system integration.

## Brief Overview of EE Graduate Program

Applications for admission should be directed to the Graduate School which maintains all necessary information such as deadlines, requirements etc. The department offers M.S., M.E., and Ph.D. programs. Upon admission, the M.E. degree requires satisfactory completion of 30 credit hours of course work and does not have a thesis requirement. The M.S. degree has 24 credit hours coursework and 6 hours of thesis requirement. For both the M.S. and M.E. degrees the student must pass a comprehensive exam.

The Ph.D. degree requires 48 credit hours of course work beyond the Bachelor's degree and a 12 credit hour dissertation. If a student enrolls with a recognized master's degree he/she would require 18 credit hours of course work and 12 credit hours of dissertation. All Ph.D. students must pass a written qualifying exam. After that the student has to write and defend his/her dissertation proposal to become a candidate. Once a candidate, the Ph.D. student has to pass a comprehensive exam set up by his/her committee. Finally the student writes his/her dissertation and defends it before his/her committee and the public.

Generally, most Ph.D. students are supported through research assistantships awarded by individual professors. Signal Integrity graduate students generally carry out industry internships that support them following their basic SI courses. Rarely do master's students receive assistantships.

## contact us

To learn more about the College of Engineering and Computing at the University of South Carolina, visit [www.cec.sc.edu](http://www.cec.sc.edu).

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The University of South Carolina is an equal opportunity institution. 10/11



## University of South Carolina – Location

The University of South Carolina is the State's flagship university located in downtown Columbia. The Columbia metropolitan area has a total population of more than 0.5 million.

The city is located 210 miles from Atlanta and 110 miles from Charlotte. The state boasts beautiful beaches that are only 120 miles from Columbia; mountains are about 120 miles to the north. The university is near many lakes, state parks, and other recreational spots for every kind of activity. Columbia downtown has great places to eat, a beautiful riverwalk, the Finlay park, and an excellent public library. Students have ample opportunities to interact with faculty and other students both inside the class and outside in various ways, including dedicated class web pages and internet blackboard. The university has more than 44,152 students and 2132 full time faculty members.

