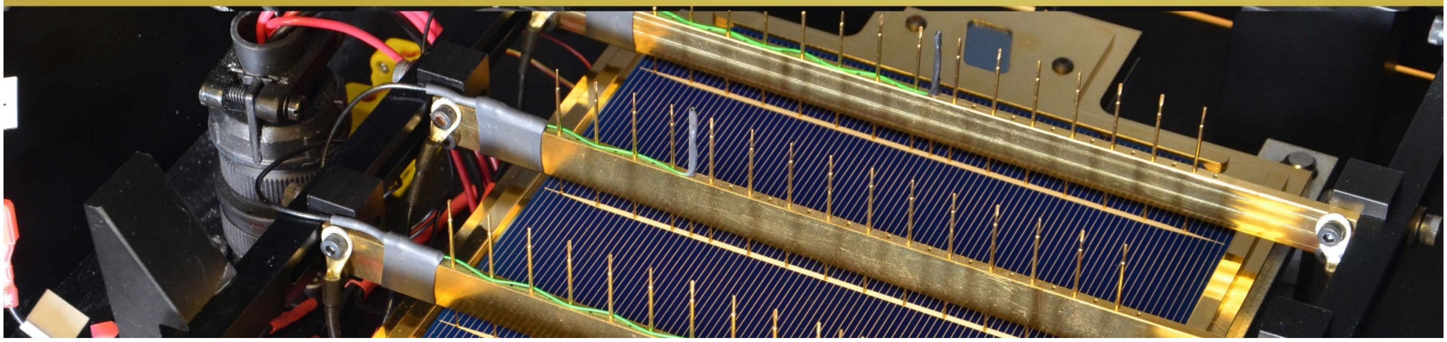
UNC CHARLOTTE

Electrical and Computer Engineering

The William States Lee College of Engineering

Newsletter 2015-2016



Professor and Chair

Dear Friends:

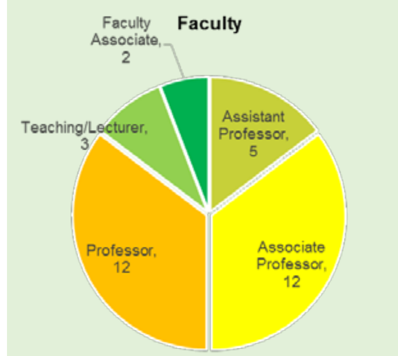
Greetings from UNC Charlotte! I am proud to share with you some of the exciting news from the Department of Electrical and Computer Engineering (ECE) of The William States Lee College of Engineering from 2015-16.

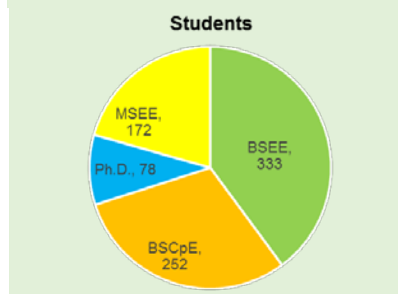
We are pleased that for the second consecutive year the enrollment in ECE's two undergraduate programs grew by more than 10% per year. In fall 2016, the department reached a total student enrollment of 838, with 585 undergraduates and 250 graduate students.

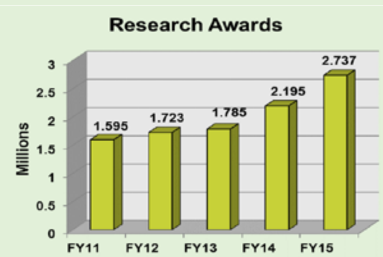
We are happy to welcome four new faculty members this year, bringing the department to 34 full time faculty. Notable accomplishments by ECE faculty this year include over 20 new research grants that were awarded in the areas of semiconductor defect studies (Dr. Zhang), transmission line modelling (Dr. Cecchi), cyber-physical systems (Dr. Adams), nanostructure design and fabrication (Dr. Fiddy), and many others. ECE faculty published a total of 26 journal and 92 conference papers this year. The NSF I/UCRC on Metamaterials and the I/UCRC on Sustainably Integrated Buildings and Sites continued to expand their activities with several new industrial collaborations. Dr. Cox was awarded the ***Charlotte Business Journal's "40 under 40"*** award, which recognizes young professionals who are making major strides in their careers and having a positive impact on their communities. Dr. Raphael Tsu was awarded the ***2016 Arts and Science Council (ASC) Honors Award*** in the field of Science, which celebrates lifetime achievements of Charlotte-Mecklenburg residents in the visual, design or performing arts, history, literature or science. Dr. Badrul Chowdhury was selected as the ***Duke Distinguished Professor.***

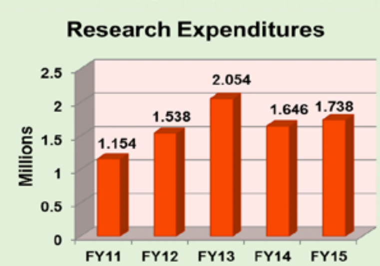
ECE students also achieved outstanding recognitions. ECE doctoral student Samuel Shue won the 2016-2017 *Lucille P and Edward C. Giles Dissertation-Year Graduate Fellowship*. ECE graduate Audrow Nash was awarded the *2016 NSF Graduate Research Fellowship*, and is pursuing his graduate studies at the University of Michigan at Ann Arbor. Doctoral students Chandrasekharan and Rajagopalan were awarded the *2016-2017 Provost's Doctoral Teaching Fellowship*.

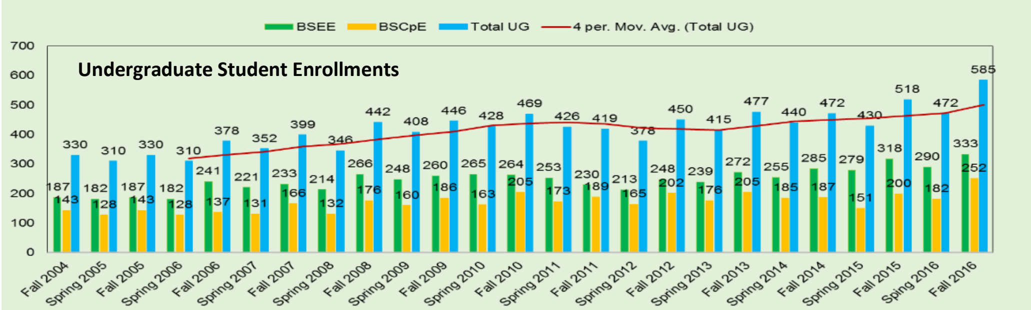
Some of the exciting accomplishments of ECE faculty are included below. I hope you enjoy reading about them.











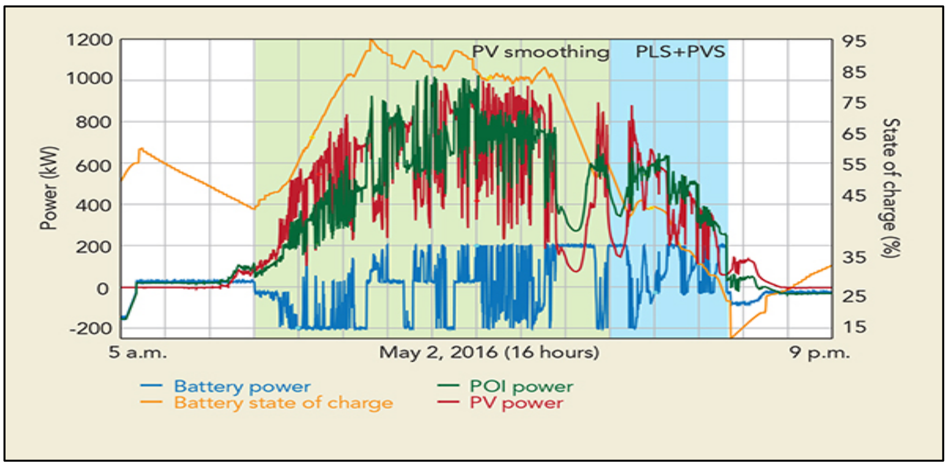
Top Stories

Battery Energy Storage System Management for Improving Distribution Power Grid Reliability

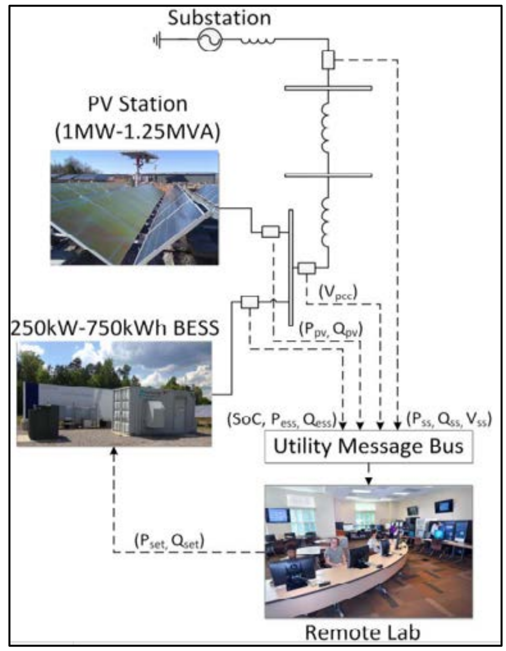
Dr. Kamalasadan and his graduate students have been working with Duke Energy to design and develop a battery energy storage controller for (a) mitigating the negative effects of the photovoltaic (PV) farm penetration to the grid, (b) shifting energy requirements at the peak load from the battery, and (c) improving the power distribution feeder voltage profile. The team is working with a battery energy storage system test bed at Duke Energy's Marshall power station that consists of a 250-kW, three-hour lithium-polymer battery system from Kokam, operated by a 1.25-MVA inverter from S&C Electric Co.

Research on photovolatic power distribution aims to minimize unavoidable PV power swings caused by cloud passing. Counteracting such swings is of the utmost importance to minimize transients caused by renewable distributed energy resources on distribution feeders. Research targets high rate power swings occurring throughout the PV plant's time of operation. Work on power distribution algorithms uses weather forecast data and neural network prediction algorithms to create systems automatically adjust discharge capabilities for PV systems to be maximum when the grid load is also maximum. Work in feeder voltage systems seek to calculate the reactive power to be injected at the POI to minimize voltage regulator tap operations throughout distribution feeders and at the same time, mitigate voltage spikes caused by the distributed renewable energy resource connected at the same bus.

This project promotes transformational change to modernize the power grid. To date, funding from this project has supported five graduate students, and academic products include four patents and over 10 journal and conferences papers.



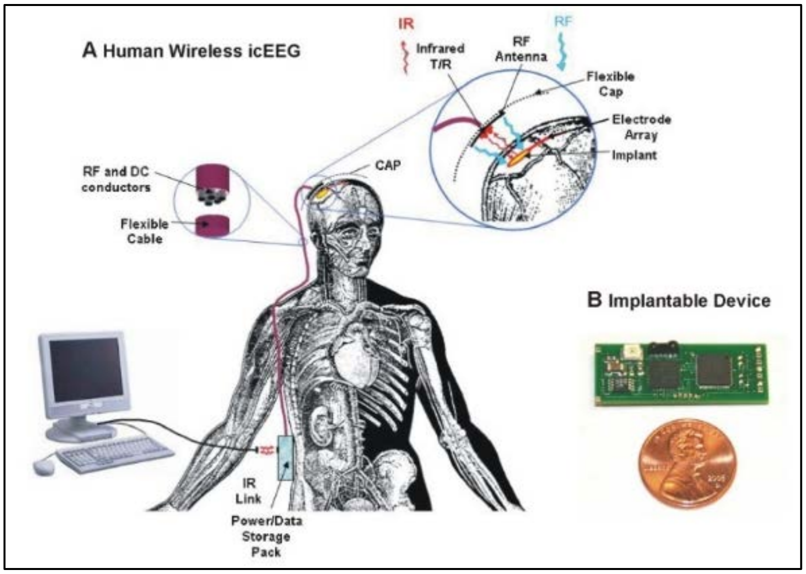
This graph shows the curves for PV station, battery energy storage system and point of interconnect (POI) powers in kilowatts. The corresponding battery state of charge is also shown in percentage for May 2, 2016, operation at Marshall. Both PV smoothing



Implementation Infrastructure and remote connection to Duke Energy Smart Grid Lab

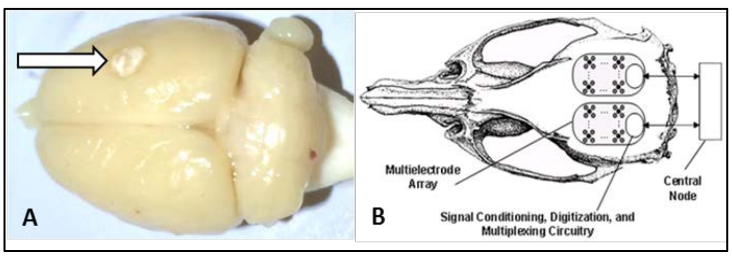
Fault-Tolerant Brain Implantable Cyber-Physical System

Dr. Ryan Adams, in collaboration with Yale University, has received funds from the National Science Foundation to develop brain-implantable sensing and stimulating devices based on emerging cyber-physical system principles and practices for the evaluation and treatment of episodic brain disorders such as epilepsy. Such disorders have considerable impact on a patient's productivity and quality of life and may be life-threatening when seizures cannot be controlled with medications. The devices are composed of modules placed intracranially to continuously monitor brain state and vulnerability to seizure and intervene with electrical stimulation to block the development of seizure events. We begin with safety and efficacy evaluation in a rat model of epilepsy (as shown below), with safety evaluation in sheep, and clinical testing in patients being conducted in future phases of work. This roadmap is designed to meet regulatory needs to demonstrate safety and efficacy prior to testing and use in humans. In this phase of the work we are developing and testing a fully functional miniaturized device for a rat model of epilepsy. Importantly the design is scalable, certifiable, interoperable, and dependable. These essential cyber-physical system aspects allow programmatic scaling from rat to sheep and then to human with efficient re-use of developed modules.



(A) Schematic of brain implantable 64 channel, battery-free, wireless digital icEEG acquisition system developed for humanicEEG measurement. The device can condition, digitize and transmit digital icEEGs over an infrared link, be powered by RF, external wired power, or an integrated battery and used for animals or humans. (B) Implantable 64-channel icEEG recording device compared to a USA penny. The circuit board dimensions are 1.3 cm x 3.4 cm x 0.5 cm. The circuitry is built from current off-the-shelf (COTS) discrete technologies.

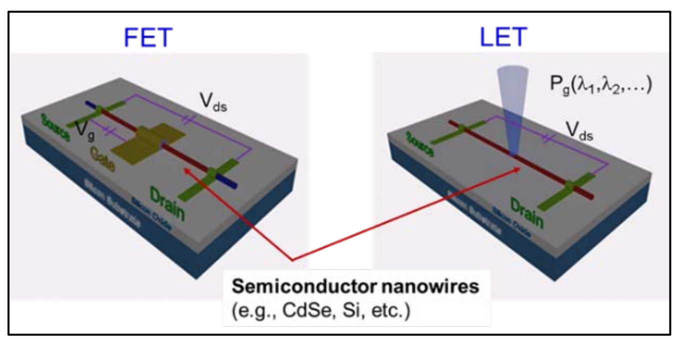
There are a number of shortcomings of the current methodology for intracranial EEG (icEEG) monitoring (many of which are shown in the figure below) that increase morbidity, restrict mobility, as well as many other serious limitations. These limitations could be considerably reduced by the wireless transmission of icEEGs from intracranial sensors to recording equipment external to the brain. We have developed a 64 channel wireless icEEG device for this purpose. The device was miniaturized to allow testing in the rat. We now seek to adapt this solution to make a brain-implantable sensing and stimulating device to control seizures.



A. Stroke created on right hemisphere. B. Placement of the implantable system. There will be two thin-film grid electrodes, one per hemisphere, each with 8 x 4 primary contacts. The central node will be placed subcutaneously behind the shoulder.

Light Effect Transistor (LET) for high-speed low-energy computing

Prof. [Yong Zhang's](#) group recently proposed a novel electronic-optical hybrid device, light-effect transistor (LET), as an alternative for the well-known field-effect transistor (FET) and other electronic devices. LET has various advantages, such as high speed (capable of THz switching speed) and correspondingly much reduced switching energy, and the feasibility operating in the quantum region. The prototype devices were fabricated using high quality CdSe nanowires in a simple M-S-M structure. LET offers additional unique capabilities, such as optical logic gates and optical amplification. The work has been published in [Frontiers in Physics](#) with his collaborators.

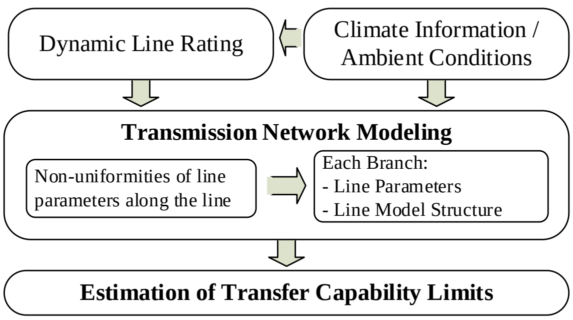


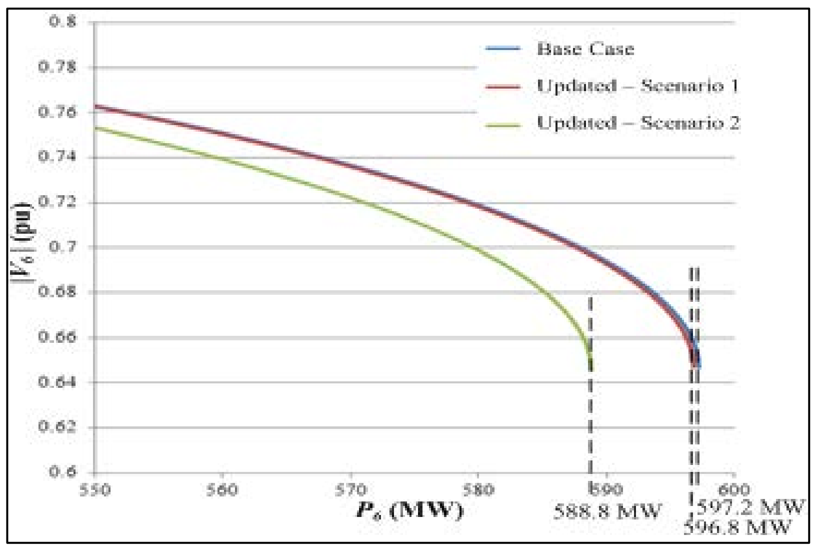
Recently, in collaboration with two external groups, his group has also started a new project funded by ARO to carry out correlative study on individual defects in semiconductor materials and devices, which aims to achieve fundamental understanding on how an individual defect impacts device performance.

Adaptive Determination of Transmission Network Models for Optimized Use of Existing Transmission and Distribution Assets

Dr. Valentina Cecchi has received funds from the National Science Foundation to investigate the coupling of dynamic line ratings systems and temperature-dependent electric power transmission line models. By increasing the level of detail in the line models, and removing select historical modeling assumptions, this project aims at developing models that take into account available information including ambient conditions, to result in more accurate determination of the network operating conditions. Specifically, the project plans to investigate and formulate the coupling of temperature-dependent transmission line models that are able to account for longitudinal non-uniformities in line parameters, with dynamic line rating techniques, leading to a novel methodology to estimate transmission network parameter and model structure of an electric power system. This would result in increased accuracy in estimates of network loading capabilities and system voltage stability indices. These research activities will provide a framework to study electric power systems by incorporating environmental conditions as new degrees of freedom, which results in optimized use of the power delivery infrastructure, allowing for more reliable, efficient and cost-effective delivery of electricity.

For further information, contact Dr. Cecchi (vcecchi@uncc.edu).

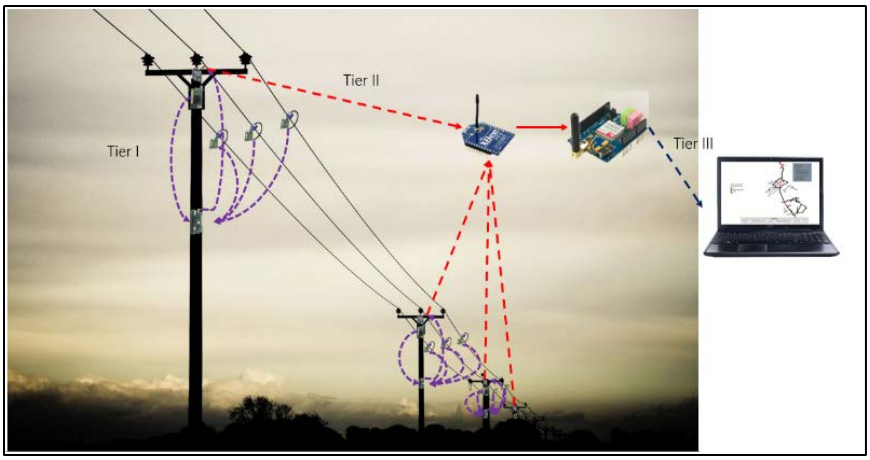


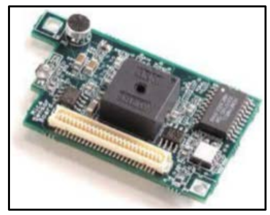
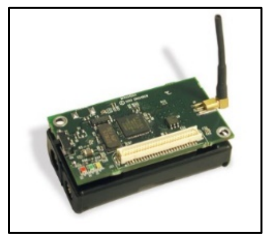


Improving Resiliency of the Power Grid

Hurricanes, ice storms, tornadoes, and other significant high-impact, low frequency (HILF) weather events have been known to cause massive disruptions in power leading to significant customer miseries in the recent past. The power grid is inherently vulnerable to outages considering the fact that thousands of miles of critical current-carrying wires are exposed to the elements. This fact coupled with the realities of an aging infrastructure and continuously changing operating dynamics and constraints render the power grid fully exposed to the forces of nature.

A multi-disciplinary team of professors from Electrical & Computer Engineering (Drs. Chowdhury and Nasipuri), Systems Engineering & Engineering Management (Dr. Lim), and Computer Science (Dr. Subramanian) have recently initiated a project on improving the resiliency of the power grid. The main goal of this project is to develop optimal reconfiguration and constrained resource distribution to maximize the availability of power to critical loads based on intelligence gathered from a wireless sensor network (WSN) during disturbance events. The grid resiliency improvement solution features potential use of distributed energy resources (DER) as well as the emerging concept of a microgrid operating within a WSN for enhanced responsiveness and faster restoration of power to critical loads (such as, healthcare facilities, law enforcement, natural gas delivery network, gasoline pumping stations, water distribution facilities, etc.). A multi-tiered wireless sensor network is being designed that will have the ability to report to the substation with information on the attributes of an outage, including location, possible extent of the outage, and potential use of DER for backup power. The wireless sensor nodes used in this system are developed using off-the-shelf low cost wireless sensor nodes that are equipped with Rogowski coils and MEMS based tilt sensors. A fault location algorithm takes the sensor data as input and provides a clear indication of faults on the feeder. The solution will eventually have the capability for massive mobilization of DER through reconfiguration of power lines and mobile backup power generation (residential/commercial rooftop and community solar plants, plug-in electric vehicles (PEV), and portable diesel generators) in order to provide power to critical loads, such as healthcare network, natural gas delivery network, gasoline pumping stations, water distribution facilities, etc. A software-based visualization tool provides easy access to sensor data and provides dynamic displays of the system operation as it unfolds.



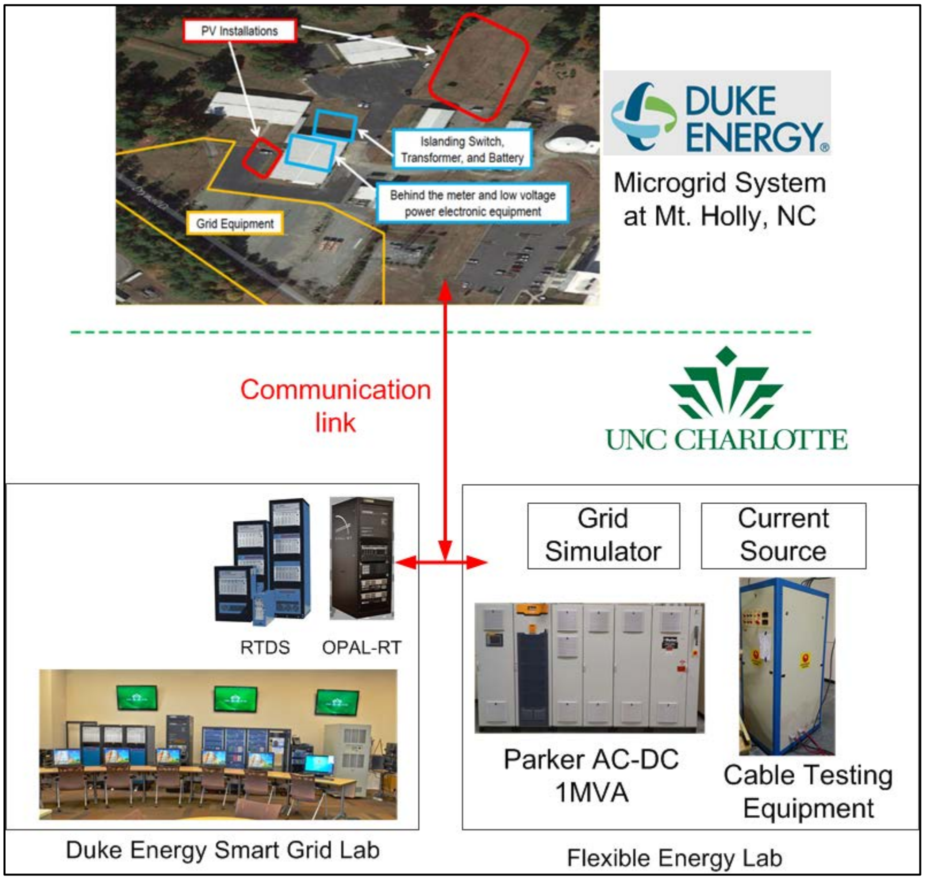



Multi-tiered wireless sensor network and network components for monitoring information on power outages.

Development of a Virtual Lab Environment at UNCC in collaboration with industry partner Duke Energy

In a changing electric power system increasing amounts of distributed energy resources have presented numerous technical challenges both for engineers in academia and the utility industry. To tackle some of the major problems we need a platform on which new innovative algorithms can be tested and validated before they are deployed to the field. UNCC and industry partner Duke Energy Corporation have come together to develop such a platform, called a Virtual Lab Environment, which integrates the strengths of these two organizations without duplicating each other’s efforts. ECE faculty Dr. Madhav Manjrekar is spearheading this effort from the UNCC side.

The Virtual Lab Environment (VLE) integrates the Duke Energy's Mt. Holly microgrid system and UNCC's Smart Grid and Flexible Energy Labs. The Mt. Holly microgrid system consists of distributed energy resources such as solar photovoltaic systems, battery energy storage systems, and electric vehicle chargers. The Smart Grid Lab has capabilities such as real-time digital simulator (RTDS) and Opal-RT which emulate real world power systems and power electronics to a high degree of accuracy. The Flexible Energy Lab, has hardware capabilities such as a grid simulator which can replicate real-world voltages, and a current source capable of producing up to 4000 A.



By connecting these research facilitiess together a novel context for microgrid management algorithm development is created. Algorithms developed at UNCC can be tested first in simulation, then in hardware and finally implemented in Mt. Holly. This VLE promises to be a great platform for engineers working to solve the power grid's biggest problems and also serves as an excellent educational platform to nurture the electrical engineers of the future.

New ECE Media Lab and Audio Engineering Courses Developed

The ECE Media Lab includes a variety of equipment for studying acoustics and audio. Two new ECE senior elective courses have recently been developed around this laboratory. Both of these courses will be offered in academic year 2017-18 as "special topics", but proposals are being finalized to place them permanently in the catalog. The first course is "Digital Audio Workstations". The second course is "Audio Engineering and Electronic Music Synthesis". A third course, ECGR 4122 "Acoustics" has been dormant in the catalog for a while and is now being taught again with regularity.

In "Digital Audio Workstations" (proposed ECGR 4311), students work with Pro Tools software to learn how to record and manipulate complex audio tracks using sophisticated editing techniques and a variety of software "plug-ins". This requires interacting with Pro Tools using audio interface hardware along with external sound sources. A class project consists of a recording session where the students serve as both musicians and audio engineers. Many of our students and faculty are good musicians! This course culminates in the opportunity to earn a "Pro Tools User" certificate through a standardized test.

In "Audio Engineering and Electronic Music Synthesis" (proposed ECGR 4312), students learn about the basic components of audio hardware, including microphones, mixers, compressors, and equalizers. Laboratory work is conducted to characterize each of these elements using an HP8903 Audio Analyzer. The elements of electronic music synthesis are studied, and a simple synthesizer is built in LabView. Modular synthesis is explored both through software and hardware. Finally, the cutting edge of human-machine interface is investigated using the Continuum fingerboard and its Eagen Matrix software interface.

Students work on their final class project mixes

New Faculty in 2016

Dr. Yawo Amengonu
Teaching Assistant Professor
Ph.D., University of North Carolina at Charlotte, 2015

<u>Research Interests:</u> Geometric Methods for Control of Underactuated Dynamical Systems

Dr. Jeremy Holleman
Associate Professor
Ph.D., University of Washington, 2009

<u>Research Interests:</u> Analog CMOS design, novel devices for design

Dr. Hamed Tabkhi
Assistant Professor
Ph.D., Northeastern University, 2014

<u>Research Interests:</u> Geometric Real-time embedded vision, domain-specific computing, mobile-edge computing, cyber-physical systems

Dr. Teifu Zhao
Assistant Professor
Ph.D., North Carolina State University, 2010

<u>Research Interests:</u> Grid edge power electronics, solid state transformers and circuit protection, renewable energy integration and microgrid

Other News

- Dr. James Conrad started his term as ***Director of IEEE Region 3*** on January 1, and will continue in this role until December 31, 2017. In this position he is the leader of the 26,000 IEEE members in the Southeast USA, and also sits on the International Board of Directors of IEEE, a 425,000 member professional organization for the Electrical and Computer Engineering practitioners.

- ECE doctoral student Mehrdad Biglarbegian won the *Best Paper award* in the *IEEE Applied Power Electronics Conference (APEC),* Anaheim, CA, 2016, for their paper “Optimized power embedded inductors for high frequency DC/AC converters”. His co-authors were Neel Shah, Iman Mazhari, Johan Enslin and Babak Parkhideh.
- ECE students Paul Rankin, Estefano Joniaux, and Jonathan Tribble won the *First Prize* in the undergraduate poster presentation in the *IEEE Power and Energy Society’s T&D Conference and Exposition* in Dallas, TX, May 2-5, 2016, for the project “Implementation of an IDMS for Volt/VAR Optimization Testing”.
- ECE students Layton Hall and Hunter Damewood won the *Third Prize* in the undergraduate poster presentation in the *IEEE Power and Energy Society’s T&D Conference and Exposition* in Dallas, TX, May 2-5, 2016, for the project “Implementation of an IDMS for Volt/VAR Optimization Testing”.
- Dr. Robert Cox developed ***Envision Charlotte***, a non-profit organization that attempts to integrate education and research for the improvement of efficient energy usage, reduce waste, conserve water usage, and improve air quality in the Charlotte region. Envision Charlotte works in coalition with Envision America, a program developed in partnership with the White House Office of Science and Technology, which is intended to copy the Envision Charlotte model to various cities across the USA. Dr. Cox’s work was highlighted in Politico Magazine in November 2015 (http://www.politico.com/magazine/story/2015/11/the-smart-city-that-doesnt-mind-being-a-little-less-bright-213369).
- Under the leadership of Dr. Johan Enslin, UNC Charlotte continued to be an active member of the ***Center for Advanced Power Engineering Research (CAPER)***. CAPER is a membership driven consortium among several universities and industry partners in the Southeast region of the US. The main mission of the center is to develop and demonstrate grid modernization technologies and enhance the educational experience for students in electric power engineering.
- Dr. Mike Fiddy received the ***Phase-II award for the NSF I/UCRC Center for Metamaterials***, which involves industrial support from companies such as Raytheon, Corning, AFRL, US Army CERDEC, and ARO. Dr. Fiddy has assumed the role of the Center Director for this multi-university Research Center this year.
- Dr. Robert Cox served as the ***Interim Vice President of Engineering at SineWatts Inc.***, a locally incubated startup that was developed with funding received from Department of Energy’s Sunshot initiative.
- Dr. James Conrad from ECE, Dr. Browne from the ETCM Department, and the College of Engineering organized the three-day state finals competition for ***FIRST NC Robotics*** this year. The competition was held in the Halton Arena. As part of the program, the 1000 participants and their parents were treated to a welcome dinner and tour of the Engineering campus and buildings.
- The ECE department organized and ran a LEGO MindStorms Robotics building workshop and a part of the ***2016 NC Science Festival***. Over 220 children and parents visited the EPIC building to participate in this day-long workshop, which was held on two days in mid-April. Volunteers from the UNC Charlotte Robotics Club worked with the child/parent pairs to learn about building and running robots.
- The ECE Department provided robotics and electrical engineering educational opportunities for over 200 children in summer 2015. The EE department works with the ***UNCC Camps on Campus*** program to provide educational content over 11 camps, each of them a week long. In 2016, the ECE department will run 13 weeks of camps for the Camps on Campus program.