

CAPER

**Center for Advanced Power
Engineering Research**

UNC Charlotte Power Curriculum

Presented By:

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Spring Meeting, March 20, 2017

Outline

- EE Curriculum
- Power Courses at the Undergraduate and Graduate Levels
- EPIC and its role in energy education
- UG concentration in power and energy
- Course diversity
- Lab facilities
- Senior design projects in power and energy
- Sunshot (GEARED/GridEd) workforce development effort and impact on the curriculum

EE Curriculum: Yrs. 1 and 2

Course Number	Course Title
<i>Fall Semester</i>	
UWRT 1101	Writing and Inquiry in Academic Contexts I
ENGR 1201	Introduction to Engineering Practices and Principles I
CHEM 1251	Principles of Chemistry
CHEM 1251L	Principles of Chemistry Lab
ECGR 2103	Computer Utilization in C++
MATH 1241	Calculus I
<i>Spring Semester</i>	
UWRT 1102	Writing and Inquiry in Academic Contexts II
ENGR 1202	Introduction to Engineering Practices and Principles II
PHYS 2101	Physics for Science and Engineering I
PHYS 2101L	Physics for Science and Engineering I Lab
LBST 110X	LBST 1100 Series: Arts and Society
MATH 1242	Calculus II

Course Number	Course Title
<i>Fall Semester</i>	
ECGR 2111	Network Theory I
ECGR 2155	Instrumentation and Networks Laboratory
ECGR 2181	Logic Systems Design I
MATH 2171	Differential Equations
PHYS 2102	Physics for Science and Engineering II
LBST 2101	Western Cultural and Historical Awareness
<i>Spring Semester</i>	
ECGR 2112	Network Theory II
ECGR 2156	Logic and Networks Laboratory
ECGR 2252	Electrical Engineering Design I
MATH 2241	Calculus III
PHYS 3141	Introduction to Modern Physics
MATH 2164	Matrices and Linear Algebra

ECE Curriculum: Yrs. 3 and 4

Course Number	Course Title
<i>Fall Semester</i>	
ECGR 3111	Signals and Systems
ECGR 3121	Introduction to Electromagnetic Fields
ECGR 3131	Fundamentals of Electronics and Semiconductors
ECGR 3155	Systems and Electronics Lab
STAT 3128	Probability & Statistics for Engineers
LBST 221X	LBST 2200 Series: Ethical Issues and Cultural Critique
<i>Spring Semester</i>	
ECGR 3122	Electromagnetic Waves
ECGR 3132	Electronics
ECGR 3142	Electromagnetic Devices or ECGR 3133 Solid State Microelectronics
ECGR 3156	Electromagnetic and Electronic Devices Laboratory
ECGR 3112	System Analysis II or ECGR 3181 Logic System Design II
ECGR 3157	Electrical Engineering Design II
ENGR 3295	Professional Development

Course Number	Course Title
<i>Fall Semester</i>	
ECGR 4241	Electrical Engineering Senior Design I
ECGR 4123	Analog and Digital Comm. or ECGR 4124 Digital Signal Processing
ECGR 4XXX	4000 Level ECGR Course
ECGR 4XXX	4000 Level ECGR Course
XXXX XXXX	Technical Elective
LBST 2102	Global and Intercultural Connections
<i>Spring Semester</i>	
ECGR 4242	Electrical Engineering Senior Design II
ECGR 3159	Professional Practice
MEGR 3111	Thermodynamics I
ECGR 4XXX	4000 Level ECGR Course
ECGR 4XXX	4000 Level ECGR Course
ECON 2101	Principles of Econ. Macro or ECON 2102 Principles of Econ. Micro

Power Courses at the Undergrad Level (1)

1. Electromagnetic Devices (3 Cr.; twice/yr) **Semi-required**
2. Introduction to Energy Systems (3 Cr.; once/yr)
3. Power Systems I (3 Cr.; once/yr)
4. Power Systems II (3 Cr.; once/yr)
5. Energy Markets (3 Cr.; once/yr)
6. Computational Methods in Power Systems (3 Cr.; once/2yr)
7. Dynamics and Trans. Analysis of Power Systems (3 Cr.; once/2yr)
8. Power Generation Operation and Control (3 Cr.; once/yr)

Power Courses at the Undergrad Level (2)

- 9. Power Electronics I (3 Cr.; once/yr)
- 10. Utility Applications of Power Electronics (3 Cr.; once/yr)
- 11. Electric Machines (3 Cr.; once/yr)
- 12. Renewable Energy (3 Cr.; once/yr)
- 13. Science and Technology of PV (3 Cr.; once/yr)
- 14. HVDC Transmission and Technology (Occasional)
- 15. Distributed Generation and Storage (Occasional)

Courses at the Grad Level

1. Power Quality
2. Power Electronics II
3. Symmetrical Components
4. Power System Relaying
5. Electric Power Distribution Systems I
6. Electric Power Distribution Systems 2
7. Smart Grid: Characteristics, Design, and Analysis
8. Power System Stability and Control
9. Solid State Circuit Protection for AC and DC Distribution Systems
10. Three-Phase Power Converters



EPIC and its Role



- EPIC and its role in energy education
 - Founded by the energy industry for workforce development, economic development and applied research in energy
 - 25 Cluster hires (most within last four years)
 - Energy concentrations
 - EPIC Scholarships
 - EPIC Undergraduate Research Assistantships



UG Concentration in Power

- Students must enroll in the following core courses
 - Electromagnetic Devices
 - Power System Analysis II
- Students must enroll in the following **technical electives**:
 - Power Systems Analysis I
 - Power Electronics I
 - Control Systems Theory I
 - Linear Algebra
 - Two additional technical electives at the senior level in power (6 hrs)
 - Two-semesters of energy-related senior design project (5 hrs)

> **Junior year**

Course Diversity



- Technical electives

(course title, **#UG enrolled in previous semesters**)

- Introduction to Energy Systems **(4, 9, 17)**
- Power Generation Operation and Control **(0, 1, 3)**
- Power System Analysis I **(16, 21, 31)**
- Power System Analysis II **(10, 12, 14)**
- Power Electronics **(15, 15, 22)**
- Electric Machinery **(17, 7, 7)**
- Utility Applications of Power Electronics **(0, 2)**
- Energy Markets **(5)**

Lab Facilities – Teaching Power Lab

- Modular benches for systems and electromechanical energy conversion principles
- Equipment can be configured to create exercises for
 - Electric machines and drives
 - Power systems
 - Microgrid management, distributed generation, renewable energy integration, energy storage, etc.



Senior Design



- Senior capstone design projects in power and energy
 - Real-world engineering projects
 - Multi-disciplinary teams are encouraged with a typical team of four to six students.
 - Two full semesters of approx. 250 hours per student to their projects
 - Follow formal process from project plan to concept generation to working prototype.
 - Industry mentor + faculty advisor
 - Coaching and instruction to stay on track
 - Industry sponsored
 - Design expo – showpiece event



Senior Design Projects in Power and Energy

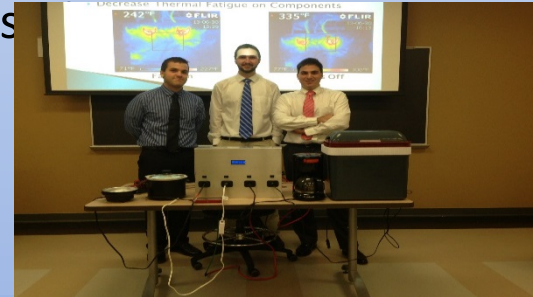
- Analysis of Large Scale Renewable Energy - Duke Energy
 - develop real-time dynamic models of large-scale renewable energy resources, including relevant T&D models
- Open Phase Event Study and Detection – AREVA
 - Using EMTP software, analyze several configurations, loading conditions and transformer core designs for an open-phase event in or near the switchyard of an generating station.

Senior Design Projects in Power and Energy

- Wave Energy Conversion – Enventys
 - Use energy in waves to produce and store compressed air that will in turn drive a reverse osmosis unit for desalination of sea water
- Quad Copter for NDE – EPRI
 - Design an automated inspection device that utilizes a climbing device which implements a central vacuum chamber surrounded by a rolling foam seal in order to provide a seal and propulsion capability.
- Torsional Sensor Demonstration Unit – EPRI
 - Identify the torsional natural freq. of T-G shafts by measuring the spectrum of dynamic shaft strain using a wireless strain-gage system

Senior Design Projects in Power and Energy

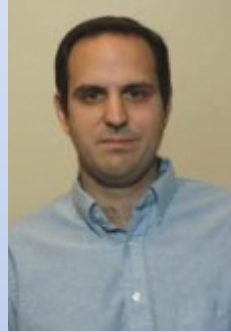
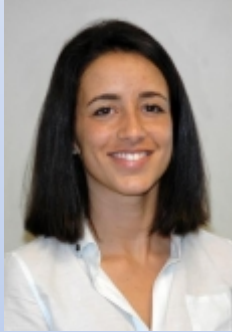
- Design Optimum Emergency Power Source Using Existing Automobiles – EPRI
 - Design an efficient power conversion capability to provide emergency power from vehicles for residential loads
- Design of a High Efficiency, Cost Effective Portfolio of DC Powered Loads for Residential Customers – EPRI
 - Design an optimum 12-V DC portfolio that could be used as a backup option to serve residential loads.



Conclusions

- Even though enrolment in power courses is high, the number of students enrolled in the UG concentration is still low.
- Concentration students were some of the top undergraduate students
 - GPA >3.5
 - All had multiple job offers.
 - 2 students received the IEEE PES Scholarship.
- About a third of senior design projects are in power
- EPIC and GridEd are creating new opportunities in power curriculum enhancement

ECE Power Area Faculty



Backup Slides

GEARED Project



- Workforce development in distributed renewable energy integration (began in late 2013)
 - Distributed technologies (distributed generation and storage)
 - Renewable energy technologies
 - Electric vehicles
 - Power electronic interfaces for PHEV and renewables
 - Smart grid (power systems that are able to operate in an integrated fashion with these distributed technologies)
- EPRI, as the lead, has partnered with 4 universities and 12 utility companies to create this consortium.
 - There are three other such consortia in the country.





(Project lead)



UNIVERSIDAD de PUERTO
RICO Mayaguez

Plus

Central Hudson, Consolidated Edison, Inc., CPS Energy, Duke Energy, DTE Electric Company, FirstEnergy, LG&E and KU Energy, Lincoln Electric System, National Grid, New York ISO, New York Power Authority, Southern Company



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