Course Syllabus

Special Topics: Integration of Distributed Energy Resources

Course Coordinator:	Local instructor at each participating school
Catalog Description:	Analysis and design of power systems in presence of distributed generation with focus on modeling, control and protection systems.
Credit Hours	3
Prerequisite(s) by course	Introductory course in electric power systems (school specific)
Prerequisite by topics	Power System Design and Analysis, techniques for sinusoidal steady-state analysis of three phase systems, power-flow and short-circuit analysis
Required Textbook	None
Other Materials	Class content will be posted on class management system (BB or Canvas).

Learning Outcomes:
Undergraduate students who successfully complete this course will be able to:

1. Explain the fundamental technology challenges associated with the use of energy storage such as interconnection and operational configurations, regulatory and policy issues, cost models and economic evaluations
2. Implement a grid control scheme using fundamental algorithms considering tradeoff between centralized and distributed approaches
3. Apply data analytics to improve power systems performances
4. Explain how demand response can improve grid performance
5. Design protection systems for distribution grids that contain distributed energy resources
6. Name and explain standards that apply to grid interconnection of distributed energy resources
7. Assess some of the cyber security risks introduced by a distributed energy resource

Graduate students who successfully complete this course will also be able to:

1. Lead a team to design a distributed energy resources system considering regulatory, security and technical constraints and present the results

Course Topics:

- Distributed generation characteristics and fundamental components
- Modeling and simulation of distributed generation effects on power system operation
- Role of energy storage
- Control solution for distributed energy resources
- Protection systems
- Introduction to the standards for interconnecting distributed resources with electric power systems

- The role of markets and policies
- Cybersecurity in power systems

Course Contribution to Program Outcomes:

ELCT 559 contributes to an achievement of:

- Outcome 1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
- Outcome 2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
- Outcome 5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives

Course Delivery

- This course uses a combination of live, real-time instruction as well as asynchronous student discussion board response via an online class management system (e.g. Blackboard or Canvas, specific site TBD). Methods to be used include live lectures and discussions, "voice-over PowerPoint" presentations, and written assignments.
- Student-to- Module-Instructor Interaction: Students will listen/view lectures online (voice-over PowerPoint) and interact with the module instructor through discussion board and emails. Module Coordinators and/or Instructors will post weekly prompt(s) and respond to student postings. The instructor will post weekly announcements, provide individual feedback to students, and hold online office hours.
- Student-to- Local-Instructor Interaction: Students will meet (face to face) weekly with the local instructor to review the class material
- Student-to-Student Interactions: Students will engage in discussions with other students, including throughout the FEEDER consortium, via the discussion board.
- Student will work with students at other universities on the final project
- Student to Content Interaction: Students will engage with course content by completing reading assignments, listening/viewing Module Instructor presentations, writing discussion boards postings, and completing homework assignments, and contribute to the work of a project team.

Technology Requirements

Basic online technology skills are needed for this course, as well as a capability to learn and use All work in this course must be completed and submitted online. Therefore students MUST have consistent and reliable access to a computer and the internet. Before starting this course, students must feel comfortable doing at least the following:

- Create, organize, and save electronic files,
- Download and upload documents to a classroom management system
- Learn to build and operate a system model in a grid simulation tool.

The course will use the following two simulation packages:

- Matlab/SimPowerSystems (each participating school has a site license), and
- OpenDSS (free, open source).

Course Assessment

Homework will normally be assigned every week. Problem solutions must show a clear and systematic method for arriving at the correct solution for full credit. Grading criteria, in the form of a rubric, will be provided for each assignment.

A final exam will be assigned at the end of the class and will include all topics covered in the course.

A group project will be assigned near the middle of the semester, due at the end of the semester. Each group will be composed of students from several universities, a group leader, usually a graduate student, will be responsible for group coordination and organization and reporting of the project. Undergraduate team members will be responsible for specific technical tasks. The project will be graded differently for undergraduate and graduate students to reflect the different requirements and responsibilities.

	Undergraduate	Graduate
Homework	40%	20%
Final Exam	20%	20%
Project	40%	60%

Final Grade	**Semester Average**
A	$100 \geq$ S.A. ≥ 91
B+	$90 \geq$ S.A. ≥ 86
B	$85 \geq$ S.A. ≥ 81
C+	$80 \geq$ S.A. ≥ 76
C	$75 \geq$ S.A. ≥ 71
D+	$70 \geq$ S.A. ≥ 66
D	$65 \geq$ S.A. ≥ 61
F	$60 \geq$ S.A. ≥ 00

Contacts

Instructor	**School**	**Email**
Aleksandar Dimitrovski	University of Central Florida	
Andrea Benigni	University of South Carolina	
Babak Fahimi	UTD	
Damla Turgut	University of Central Florida	
Eduard Muljadi	Auburn University	
Herb Ginn	University of South Carolina	
Juan Balda	University of Arkansas	
Mark Halpin	Auburn University	
Omar Faruque	Florida State University	
Paul Dolloff	University of Kentucky	
Qifeng Li	University of Central Florida	
Qun Zhou	University of Central Florida	
Reza Ghorbani	University of Hawaii	
Robert Kerestes	University of Pittsburg	
Roy McCann	University of Arkansas	
Sridhar Seshagiri	SDSU	
Wei Sun	University of Central Florida	
Yuan Liao	University of Kentucky	
Zhihua Qu	University of Central Florida	

Course Outline/Schedule

Topics for each class meeting are listed below. Circumstances may call for a departure from this schedule. Any changes to the schedule will be clearly announced via the online class management system. Homework assignments will be made at least one week prior to the due date.

Date	Topic	Instructors (leader bold)	Videos, Lectures, Reading, HWs	Learning Minutes	Learning Minutes per Week
Week 1	Characteristics of DER	All for the intro. Eduard Muljadi	Video Module 1	60	
			Reading 1	145	
			Online discussion	50	
			Class discussion	50	
			HW 1	145	450
Week 2	Characteristics of DER	Eduard Muljadi Herb Ginn	Video Module 2	60	
			Reading 2	145	
			Online discussion	50	
			Class discussion	50	
			HW 2	145	450
Week 3	Modeling and Simulation of DER	Robert Kerestes Sridhar Seshagiri Wei Sun	Video Module 3	60	
			Reading 3	145	
			Online discussion	50	
			Class discussion	50	
			HW 3	145	450
Week 4	Energy Storage	Babak Fahimi Juan Balda Paul Dollaf	Video Module 4	60	
			Reading 4	145	
			Online discussion	50	
			Class discussion	50	
			HW 4	145	450
Week 5	Distribution Automation and Control	Yuan Liao Qifeng Li Andrea Benigni Babak Fahimi	Video Module 5	60	
			Reading 5	145	
			Online discussion	50	
			Class discussion	50	
			HW 5	145	450
Week 6	Advanced Control Solution	Zhihua Qu	Video Module 6	60	
			Reading 6	145	
			Online discussion	50	
			Class discussion	50	
			HW 6	145	450
Week 7	Data Analytics	Qun Zhou Damla Turgut	Video Module 7	60	
			Reading 7	145	
			Online discussion	50	
			Class discussion	50	
			HW 7	145	450
Week 8	Policy and pricing methodologies	Paul Dolloff	(insert week 8 rows here)		450
Week 9	Demand side management	Omar Faruque Reza Ghorbani Paul Dolloff	Video Module 9	60	
			Reading 9	145	
			Online discussion	50	
			Class discussion	50	
			HW 9	145	450
Week 10	Protections	Aleksandar Dimitrovski Yuan Liao	Video Module 10	60	
			Reading 10	145	
			Online discussion	50	
			Class discussion	50	
			HW 10	145	450
Week 11	Role of standards	Omar Faruque Mark Halpin	Video Module 11	60	
			Reading 11	145	
			Online discussion	50	
			Class discussion	50	
			HW 11	145	450
Week 12	Cyber security	Roy McCann	Video Module 12	60	
			Reading 12	145	
			Online discussion	50	450

			Class discussion	50	
			HW 12	145	
Final Project					900
Total Learning Minutes					6300

Just an example

Video Modules	Title	Description-Topics
Module 1.1	Intro	All instructors provide a 2 min intro to the topic they will present in the class
Module 1.2	Photovoltaic Basics	Single cell characteristics Single cell modelling Panel and plant structure Maximum power point tracking
Module 1.3	Wind Basics	

For the reading we need to clarify how we provide material. Third party services that check for fair use is a possibility

Readings	Reference
Reading 1.1	Math H. Bollen, Fainan Hassan "Integration of Distributed Generation in the Power System", Chapter 2.2, pp.30-46

Just an example

HW projects	Title	Description
HW project 1.1	VI and VP characteristic of a PV panel	Write a Matlab (Octave) program that plot the Voltage-Current and Voltage-Power characteristics for a PV panel according to provided parameters

General Course Policies (School Specific)

Academic Integrity
Unless otherwise stated, assignments and examination work are expected to be the sole effort of the student submitting the work. Students are expected to follow the University of South Carolina Honor Code and they should expect that every instance of a suspected violation will be reported. Students found responsible for violations of the Code will be subject to academic penalties under the Code in addition to whatever disciplinary sanctions are applied.

Accommodating Disabilities
Reasonable accommodations are available for students with a documented disability. If you have a disability and may need accommodations to fully participate in this class, contact the Office of Student Disability Services: 777-6142, TDD 777-6744, email sasds@mailbox.sc.edu, or stop by LeConte College Room 112A. All accommodations must be approved through the Office of Student Disability Services.

Diversity
When scheduling exams, I have attempted to avoid conflicts with major religious holidays. If, however, I have inadvertently scheduled an exam or major deadline that creates a conflict with your religious observances, please let me know as soon as possible so that we can make other arrangements.

Deviations
Minor deviations from the syllabus are a normal part of any adaptive teaching and learning process.