CLEMSON
ELECTRICAL AND COMPUTER ENGINEERING

ECE 4160/6160: **SMART GRID**

All Sections (001, 400, 843)
SPRING 2023

MEETING TIME: Tuesdays and Thursdays, 9.30 am to 10.45 am

MEETING LOCATION: Riggs Hall 226 (in-person students)

INSTRUCTOR: Dr. G. Kumar Venayagamoorthy, Duke Energy Distinguished Professor of Electrical and Computer Engineering, Riggs 303D, Tel. 864 656-5936, email: gvenaya@clemson.edu

OFFICE HOURS AND PROCEDURES: By appointment and meeting on Zoom. Preferred is Tuesday between 8.15 am and 9.15 am. Email is the best way to contact me.

TEACHER ASSISTANTS:

Dulip Madurasinghe (dmadura@g.clemson.edu)

Office hours: T/TH: 13:00 to 15:00 – G25

EMAIL COMMUNICATIONS:

When you send me an e-mail message, use a descriptive subject line that starts with the course identifier ("ECE4160/6160"). This can significantly reduce the response time of the reply. If you do not receive a response with 48 hours, resend the message. It may have been caught in a spam filter.

COURSE MODALITY: IN-PERSON (AND ONLINE SYNCHRONOUS FOR ECE 4160 – 400)

COURSE OBJECTIVES/LEARNING OUTCOMES:

The objectives of the ECE 4160 course are to enable undergraduate students to:

- Apply the interdisciplinary concepts and smart grid technologies learned from this course to design a modern power system, the next generation intelligent grid which is a system of systems.
- Differentiate a traditional power system from an intelligent power grid.
- Be able to contribute to the transformation of a traditional power system into an intelligent power grid.
- Demonstrate the concepts of smart grid technologies via a semester-long team (4 students) project.

The objectives of the ECE 6160 course are to enable graduate students to:

- Apply the interdisciplinary concepts and smart grid technologies learned from this course to design a modern power system, the next generation intelligent grid which is a system of systems.
- Differentiate a traditional power system from an intelligent power grid.
- Be able to think through the A to Z process needed to transform a traditional power system into an intelligent power grid.
- Implement an intelligent power grid.
- Demonstrate the breadth and some depth of smart grid technologies via a working laboratory prototype semester-long team (2 students) project.

COURSE DESCRIPTION:

This introductory course on smart grid covers the concepts and technologies that transform the traditional power system into an intelligent power system (which is referred to as the smart grid today). The technologies needed for this transformation are of interdisciplinary nature and are introduced in this course.

The course specifically will cover the following topics:

- Week #1: Introduction and the traditional power system
- Week #2: Smart grid architectures
- Week #2 & 3: Intelligent measurements
- Week #3 & 4: Renewable energy sources
- Week #5: Intelligent communication systems
- Week #6: Electric vehicles
- Week #7: Intelligent power electronics
- Week #8 & 9: Computational technologies
- Week #10: Demand response management
- Week #11: Cyber and hardware security
- Week #12 &13: Data and visual analytics
- Week #13: Performance and economic analysis
- Week #14: Smart grid and ethics

Guest lectures will be offered as available during course of the semester and will be announced via Canvas.

Scheduled Guest Lectures:

- Dr. Richard Brooks - Thursday, January 19th
- Dr. Rajendra Singh - Thursday, January 26th
- Dr. Yingjie Lao – Thursday, March 9th
- Duke Energy – Thursday, March 16th
- Itron - Thursday, April 13th

COURSE PREREQUISITES:

The basic requirement is a senior undergraduate standing with MATLAB and other programming language capabilities, Microsoft Office skills (word, presentation and spreadsheet) and creation of PDF documents.

REQUIRED MATERIALS:

Students are required to have a laptop computer, internet connectivity capable of transmitting and receiving video, a video camera, a microphone, and a cell phone.

REFERENCE MATERIALS:

1. J. Momoh, Smart Grid: Fundamentals of Design and Analysis, Hoboken, NJ: Wiley, 2012. ISBN: 978-0-470-88939-8.
2. S.F. Bush, Smart Grid: Communication-Enabled Intelligence for the Electric Power Grid, West Sussex, United Kingdom: Wiley, 2014. ISBN: 978-1-119-97580-9.
3. J. Ekanayake, K. Liyanage, J. Wu, A. Yokoyama, and N. Jenkins, “Smart Grid: Technology and Applications”, West Sussex, United Kingdom: Wiley, 2012. ISBN: 978-0-470-97409-4
4. Papers from IEEExplore and Sciencedirect databases.
5. Guest Lectures
6. Additional material may be provided by the instructor.

CLASS CANCELLATION POLICY: Class is cancelled if the instructor is more than 15 minutes late to class.

GRADING POLICY:

The grading requirements are different for the undergraduate (UG) and graduate students (G).

Assignments: a minimum of 6 assignments and no more than 8

- **UG** 20%
- **G** 10%

Discussions (in-class and offline): 5%

Project (Team based):

- **UG**: no more than 4 students 25%
- **G**: no more than 2 students 35%

Tests (include quizzes): 30%

- **UG** (two tests)
- **G** (three tests)

An additional test for graduate students will be conducted.

Final Exam (comprehensive coverage of course content): 20%

Grades:

- **UG**: A – 90% - 100%; B – 80 to < 90%; C – 70 to <80%; D – 60 to < 70%; & F – < 60%
- **G**: A – 90% - 100%; B – 80 to < 90%; C – 70 to <80%; & F – < 70%

All disputes about an evaluation of any graded work during the semester must be submitted in writing (typed, not handwritten) within one week after an assignment, test or project has been distributed to students in the class. Any grade challenges must provide specific justifications for why the grade would be changed.

CLASS PARTICIPATION:

Class participation is critical to the learning process. The optimal classroom learning experience depends on both a professional teaching environment and student participation. You need to prepare prior to coming each class. Preparation includes having read the required materials or completed the expected assignments/homework. Class discussions are critical to learning and everyone in the class is expected to contribute. If you are not prepared you will weigh down the rest of the class besides losing class participation points.

ASSIGNMENT/POST/HOMEWORK:

All course submissions shall be submitted using Canvas no later than 11.55 pm of the posted due date. No late submissions beyond a day will be accepted. Late submissions require approval of the instructor and may be subjected to a 50% loss of points. Any homework assigned will not be required for submission but they are mandatory readings. Quizzes and class discussions may be based on homework (missed quizzes will have no make-ups).

TESTS AND FINAL EXAM:

Absence from the tests/final exam will be excused only for medical reasons or serious immediate family problems. A student who anticipates missing a test/exam for legitimate university or professional activities shall discuss with the instructor at least one week prior and set up an alternative arrangement to have test taken before the intended date.

If Test 1 or 2 is missed by an undergraduate student, Test #3 will be an automatic substitute to replace a missed test. If two tests are missed, then a test section will be added to the final exam for students to take. The arrangement to do so has to be approved by the instructor.

If Test 1 and/or 2 is missed by a graduate student, then a test section(s) will be added to the final exam for students to take. The arrangement to do so has to be approved by the instructor.

PROJECT WORK:

The projects will be team-based (more info to follow) and will require written reports (in IEEE PES paper format) consisting of the following items:

- Title
- Abstract
- Introduction and motivation to the project topic with references
- Development of applied theory
- Description (algorithm, flowchart) and implementation of the computer program
- Results and discussions
- Summary (including future work).

TEST/FINAL EXAM DATES (*tentative days):

- ***First Test:** Tuesday, February 14th, 2023
- ***Second Test:** Tuesday, March 14th, 2023
- ***Third Test** (graduate students only, optional for undergraduates)**:** Tuesday, April 11th, 2023
- **Final Examination:** Wednesday, May 3rd, 2023, 8.00 am to 10.30 am

ATTENDANCE POLICY:

Regular class attendance and participation including online in discussions is expected with attendance taken as iROAR requires entry of student's last date of class attendance. Students are responsible for all material covered and assigned readings during the semester. If you anticipate not being able to attend a class including online meetings for a particular reason, please e-mail me with the information (before the class to be missed). The optimal classroom learning experience depends on both a professional teaching environment and student participation.

Using the Notification of Absence module in Canvas or email to inform the instructor of student absences is required.

In case of in-person class and/or lab meetings: maintaining physical distancing required, individuals arriving first to the classroom should sit farthest from the door. Similarly, at the conclusion of class, students closest to the door should leave first.

While on campus, face coverings are required in all buildings and classrooms. Face coverings are also required in outdoor spaces where physical distance cannot be guaranteed. If a student does not have a face covering or refuses to wear an approved face covering without valid documented accommodation, the instructor will ask the student to leave the academic space and may report the student's actions to

the Office of Community & Ethical Standards as a violation of the Student Code of Conduct. If the student's actions disrupt the class to the extent that an immediate response is needed, the instructor may call the Clemson University Police Department at 656-2222.

ACCESSIBILITY STATEMENT: Clemson University values the diversity of our student body as a strength and a critical component of our dynamic community. Students with disabilities or temporary injuries/conditions may require accommodations due to barriers in the structure of facilities, course design, technology used for curricular purposes, or other campus resources. Students who experience a barrier to full access to a class should let the instructor know and make an appointment to meet with a staff member in Student Accessibility Services as soon as possible. You can make an appointment by calling 864-656-6848 or by emailing studentaccess@lists.clemson.edu. Students who receive Academic Access Letters are strongly encouraged to request, obtain, and present these to their instructors as early in the semester as possible so that accommodations can be made in a timely manner. It is the student's responsibility to follow this process each semester. You can access further information here: http://www.clemson.edu/campus-life/campus-services/sds/.

TITLE IX STATEMENT: Clemson University is committed to a policy of equal opportunity for all persons and does not discriminate on the basis of race, color, religion, sex, sexual orientation, gender, pregnancy, national origin, age, disability, veteran's status, genetic information or protected activity in employment, educational programs and activities, admissions and financial aid. This includes a prohibition against sexual harassment and sexual violence as mandated by Title IX of the Education Amendments of 1972.

SAFE CAMPUS: Clemson University is committed to providing a safe campus environment for students, faculty, staff, and visitors. As members of the community, we encourage you to take the following actions to be better prepared in case of an emergency:

a. Ensure you are signed up for emergency alerts (https://www.getrave.com/login/clemson)
b. Download the Rave Guardian app to your phone (https://www.clemson.edu/cusafety/cupd/rave-guardian/)
c. Learn what you can do to prepare yourself in the event of an active threat (http://www.clemson.edu/cusafety/EmergencyManagement/)

ACADEMIC INTEGRITY: As members of the Clemson University community, we have inherited Thomas Green Clemson's vision of this institution as a 'high seminary of learning.' Fundamental to this vision is a mutual commitment to truthfulness, honor, and responsibility, without which we cannot earn the trust and respect of others. Furthermore, we recognize that academic dishonesty detracts from the value of a Clemson degree. Therefore, we shall not tolerate lying, cheating, or stealing in any form. In instances where academic standards may have been compromised, Clemson University has a responsibility to respond appropriately to charges of violations of academic integrity. Further information on Academic Integrity can be found in the *Undergraduate Announcements* and in the *Graduate School Policy Handbook*.

COPYRIGHT STATEMENT: Materials in this course are copyrighted. They are intended for use only by students registered and enrolled in this course and only for instructional activities associated with and for the duration of the course. They may not be retained in another medium or disseminated further. They are provided in compliance with the provisions of the Teach Act. Students should be reminded to refer to the Use of Copyrighted Materials and "Fair Use Guidelines" policy in on the Clemson University website for additional information: https://clemson.libguides.com/copyright.

MODIFICATION STATEMENT: The instructor reserves the right to modify any aspect of the syllabus at any time during the semester for reasons including but not limited to COVID-related situations. *Updated:*

January 27th, 2023