Fall 2016 ECE 566
Grid Integration of Wind Energy Systems

Instructor: Prof. Siddharth Suryanarayanan
Office: Engineering C201F **Office hours:** 300PM-500PM Wednesday (Other times by appointment only)
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Lecture time and venue: Wednesday 515PM–8PM, Room: Engineering B4
Online/distance link: accessible via Canvas

Textbook: Class notes/slides by the instructor and relevant articles from public domain and electronic databases accessible via CSU libraries.

References (No need to buy):

- S. Heier. *Grid integration of wind energy conversion systems.* 2nd Ed. John Wiley & Sons: W. Sussex, England, 2006. ISBN:0470868996.
- *Wind power in power systems.* (Ed.) T. Ackermann. John Wiley & Sons: W. Sussex, England, 2006. ISBN: 9780470855089.
- J. D. Glover, M. S. Sarma, T. J. Overbye. *Power system analysis and design.* 5^{th} Ed., CL Engineering, 2012. (ISBN: 1111425779)

Prerequisites:

- *ECE461/462 Power Systems-I/Laboratory OR ECE 565 Electric Power Engineering AND
- Knowledge of Matlab® (or similar software) and PowerWorld® is necessary.

Course description: Aspects of integration of wind energy conversion systems (WECS) to electric power transmission grids. Topics include wind power plants and using wind energy, wind energy conversion systems, grid impacts of wind integration, energy storage, and control concepts of wind turbines.
Course objectives: Electricity grids are transforming to include more renewable generation sources due to increased need for energy independence and cleaner electricity production. This course is aimed at learning the underlying concepts of grid integration of wind energy conversion systems via solid theoretical and mathematical bases for wind conversion machines, operation characteristics, interfacing power electronics and controls. Upon completion of the course students will:

- Understand the basic concepts of wind energy power plants and conversion systems
- Comprehend concepts of generators and power electronics for designing WECS
- Appreciate the grid impacts of WECS including need for storage
- Learn concepts of controls associated WECS.

Assignment of course grade: The grade will be based on the weighted index as shown below.

Homework	25 %
Mid-term examination	25 %
Project: Simulation/design or Term paper	25 %
Final examination	25 %

*OR instructor's approval.

Course Outline: Tentative schedule †

Week 1	Introduction to wind power plants, history of wind energy, and growth of WECS
Week 2	Characteristics of wind power generation and basic integration issues
Week 3	Webinar-1: "Wind turbine (WT) modeling and control" Basic integration issues
Week 4 & Week 5	Generators for wind energy conversion (synchronous, asynchronous and other types)
Week 6	Overview of WT topologies and grid codes
Week 7	Grid connection of a WT (soft starter, cap banks, rectifiers and inverters, frequency converters)
Week 8	Practical case study *Mid term exam* *Project assigned*
Week 9	Power quality for wind energy conversion systems
Week 10	Power quality for wind energy conversion systems (contd.)
Week 11	Value and capacity credits for wind energy conversion systems
Week 12	Webinar-2: "Control of wind transients in small islands" Webinar-3: "Integrating wind and solar: The German experience"
Week 13	Energy storage for WECS
Week 14	*Fall break*
Week 15	Power system stability and wind energy
Week 16	*Term paper submission/presentation* Final exam

Course Policy:

Attendance: Regular attendance is strongly encouraged. Please check the Canvas site for the class, and have your preferred email account linked with Canvas for receiving all announcements. In specific, this course will include a frequently assigned (weekly) reading assignment that typically requires studying the course material equivalent to a book chapter, which includes reading and understanding the theoretical narrative of the text and relating this material to the class lectures, performing independently (by the student) the associated derivations from the textbook, and carrying out independently (by the student) the examples (worked-out problems and exercises) from the textbook and/or reference sources. The reading assignments are essential for the successful and efficient performance on projects and class participation, and as such are evaluated and assessed through all assessed/graded items included in the course outline.

Canvas use policy: The instructor will exclusively use the Canvas facility to communicate with the individual and the class regarding the course. So, it is imperative that the student has a functioning email (usually it is the colostate.edu email id) associated with the Canvas website to receive all notifications. The instructor does not take any responsibility for sending information to students via any other means or to another email id than the one associated with Canvas.

Make-up: Except under documented cases of extenuating circumstances, there will be no opportunity for a make-up for any portion of the class component towards the final grade.

ADA Statement: Students with disabilities are encouraged to register with the Office for Student Services to determine the appropriate classroom accommodations. Any student with verification of a disability should contact the instructor as soon as possible, and will be accommodated in an appropriate manner.

Project: Project: Each student enrolled in the course will be required to perform a project associated with this class. The choices for the project may be

- a simulation-based design and analysis of an engineering concept related to grid integration of wind energy conversion systems (or)
- a literature search on a contemporary topic of research interest in the field of wind energy conversion systems.

The simulation project, if chosen, is expected to be conducted on the PowerWorld® Simulator platform. The literature search project, if chosen, is expected to include high quality literature search including conclusions drawn about the state-of-the-art and the future of the topic. The instructor will assign the project/s in the 8^{th} week of classes in the semester. For the simulation project, an engineering report detailing the design and analysis of the project topic is due in the 12^{th} week of classes in the semester. For the literature search project, a research paper written using the conference template of the IEEE is a required deliverable from each student (or group) in the 12^{th} week of classes in the semester. The template will be provided to the students or can be obtained by performing a Google® search using the phrase *IEEE template*. Each student (or group) is required to present their design/paper in the form of a short presentation to the class and take questions from the audience during the 16^{th} (final) week of classes in the semester.

Academic Honesty: Academic integrity is of utmost importance. For a description on practicing academic integrity, go to: `http://tilt.colostate.edu/integrity/` Departures from accepted norms of

[†]The instructor may be on business-related travel on some of the lecture dates. In such cases of a conflict in schedule, the respective class will be recorded sans audience and made available via the class URL on Canvas. Material presented in the slides and lectures in the class are gleaned from popular resources for which the copyright is retained by the respective owner/holder/creator/publisher of the said resource. The instructor of ECE 566 does not hold any copyrights to the material obtained from the cited resources. Due credit for material derived from the references is given in each slide deck, both explicitly in the individual slide as well as in a reference section at the end of each deck. You are advised to treat the slides and lectures as education material and not to exchange, disseminate, or share them with any other entity.

academic integrity will be dealt with full compliance to CSU policies.
Colorado State University's Writing Center defines plagiarism as "the unauthorized or unacknowledged use of another person's academic or scholarly work. Done on purpose, it is cheating. Done accidentally, it is no less serious. Regardless of how it occurs, plagiarism is a theft of intellectual property and a violation of an ironclad rule demanding credit be given where credit is due."
Departures from accepted norms of academic integrity will be dealt with full compliance to CSU principles published in the CSU General Catalog (see: `http://goo.gl/7n9Sbx`).
The instructor may use an authorized software such as VeriCite^{TM}for verification of plagiarism in any work that is submitted by a student for grade in the ECE566 course. For more information on this, see: `http://info.canvas.colostate.edu/vericite.aspx`.
Visit `http://tilt.colostate.edu/integrity/pledge/wordingOf.cfm` for familiarizing with the CSU Honor Pledge.