ECE 566: Grid Integration of Wind Energy Systems

S. Suryanarayanan

Associate Professor
Department of Electrical & Computer Engineering
Outline

1. Introduction to the course
   - Instructor and lecture info
   - Text & reference info
   - Prerequisites
2. Course description and objectives
3. Course outline
4. Course policy
   - Attendance
   - RamCT use policy
   - Make-up policy & ADA statement
   - Projects
5. Academic honesty
Outline

1. Introduction to the course
   - Instructor and lecture info
   - Text & reference info
   - Prerequisites
2. Course description and objectives
3. Course outline
4. Course policy
   - Attendance
   - RamCT use policy
   - Make-up policy & ADA statement
   - Projects
5. Academic honesty
The Syllabus

Instructor information

- Office: Engineering C201F
- Office hours: 130PM–330PM Tuesday (other times by appointment only)
- Phone: (970) 491 4632; Email: sid@colostate.edu

Lecture information

- Time: 515PM–8PM Tuesday
- Venue: Engineering B4
- Online/distance link: Accessible via RamCT
Outline

1. Introduction to the course
   - Instructor and lecture info
   - Text & reference info
   - Prerequisites

2. Course description and objectives

3. Course outline

4. Course policy
   - Attendance
   - RamCT use policy
   - Make-up policy & ADA statement
   - Projects

5. Academic honesty
The Syllabus

Textbook

- Class notes/slides by the instructor and guest lecturers
- Relevant articles from public domain and electronic resources accessible via CSU Libraries

References (No need to buy)

References (No need to buy)


Outline

1. Introduction to the course
   • Instructor and lecture info
   • Text & reference info
   • Prerequisites

2. Course description and objectives

3. Course outline

4. Course policy
   • Attendance
   • RamCT use policy
   • Make-up policy & ADA statement
   • Projects

5. Academic honesty
Prerequisites

- ECE461/462 Power Systems-I/Laboratory OR
- ECE 565 Electric Power Engineering AND
- Knowledge of Matlab® and PowerWorld® is necessary.
The Syllabus

Prerequisites

- ECE461/462 Power Systems-I/Laboratory OR
- ECE 565 Electric Power Engineering AND
- Knowledge of Matlab® and PowerWorld® is necessary.
Prerequisites

- ECE461/462 Power Systems-I/Laboratory OR
- ECE 565 Electric Power Engineering AND
- Knowledge of Matlab® 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
- control concepts of wind turbines.
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
- control concepts of wind turbines.
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
- control concepts of wind turbines.
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
- control concepts of wind turbines.
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
- control concepts of wind turbines.
Upon completion of the course, you 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 with WECS.
Course objectives

Upon completion of the course, you 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.
Upon completion of the course, you 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.
Course objectives

Upon completion of the course, you 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.
Grade assignment: Option I

The grade will be based on the weighted index as shown below.

- Homework ........................................ 25 %
- Mid-term examination ....................... 25 %
- Project 1: Simulation/design ............... 25 %
- Project 2: Term paper ....................... 25 %
Grade assignment: Option II

The grade will be based on the weighted index as shown below.

- Homework ........................................ 25 %
- Mid-term examination .......................... 25 %
- Project: Term paper .............................. 25 %
- Final examination ............................... 25 %
### Course outline

<table>
<thead>
<tr>
<th>Week 1</th>
<th>Introduction to wind power plants, history of wind energy, and growth of WECS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 2</td>
<td>Characteristics of wind power generation and basic integration issues</td>
</tr>
<tr>
<td>Weeks 3 &amp; 4</td>
<td>Generators for wind energy conversion (synchronous, asynchronous and other types)</td>
</tr>
<tr>
<td>Weeks 5 &amp; 6</td>
<td>Introduction to power systems transient stability (swing equation, sync machine models, equal area criterion)</td>
</tr>
</tbody>
</table>
## Course outline (contd.)

<table>
<thead>
<tr>
<th>Weeks</th>
<th>Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weeks 7 &amp; 8</td>
<td>Multi-machine stability, 2-axis sync machine models, wind turbines machine models <em>Mid term exam</em>  <em>Simulation/design project assigned</em></td>
</tr>
<tr>
<td>Weeks 9–11</td>
<td>Power electronic concepts for wind energy conversion systems</td>
</tr>
<tr>
<td>Week 12</td>
<td>Grid effects including storage and resonance  <em>Simulation/design project due</em>  <em>Term paper assigned</em></td>
</tr>
<tr>
<td>Week 13</td>
<td>Grid effects including storage and resonance (contd.)</td>
</tr>
</tbody>
</table>
Course outline (contd.)

<table>
<thead>
<tr>
<th>Week 14</th>
<th>Fall break</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 15</td>
<td>Introduction to control concepts for wind energy conversion systems</td>
</tr>
<tr>
<td>Week 16</td>
<td>Term paper submission and presentation</td>
</tr>
</tbody>
</table>
Outline

1. Introduction to the course
   - Instructor and lecture info
   - Text & reference info
   - Prerequisites

2. Course description and objectives

3. Course outline

4. Course policy
   - Attendance
   - RamCT use policy
   - Make-up policy & ADA statement
   - Projects

5. Academic honesty
Attendance

Regular attendance is strongly encouraged. Please check the RamCT site for the class, and have your preferred email account linked with RamCT 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.
Outline

1. Introduction to the course
   - Instructor and lecture info
   - Text & reference info
   - Prerequisites

2. Course description and objectives

3. Course outline

4. Course policy
   - Attendance
   - RamCT use policy
   - Make-up policy & ADA statement
   - Projects

5. Academic honesty
### RamCT use policy

The instructor will exclusively use the RamCT Blackboard 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 RamCT Blackboard 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 RamCT Blackboard.
Outline

1. Introduction to the course
   - Instructor and lecture info
   - Text & reference info
   - Prerequisites

2. Course description and objectives

3. Course outline

4. Course policy
   - Attendance
   - RamCT use policy
   - Make-up policy & ADA statement
   - Projects

5. Academic honesty
Make-up policy

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.
Introduction to the course

Course description and objectives

Course outline

Course policy

Academic honesty

Attendance

RamCT use policy

Make-up policy & ADA statement

Projects

Outline

1. Introduction to the course
   - Instructor and lecture info
   - Text & reference info
   - Prerequisites

2. Course description and objectives

3. Course outline

4. Course policy
   - Attendance
   - RamCT use policy
   - Make-up policy & ADA statement
   - Projects

5. Academic honesty
Project 1

Each student enrolled in the course will be required to perform simulation-based design and analysis of an engineering concept related to grid integration of wind energy conversion systems. This is expected to be conducted on the PowerWorld® Simulator platform. Instructor will assign this project in the 8th week of classes in the semester. An engineering report detailing the design and analysis of the project topic is due in the 12th week of classes in the semester.
Project 2

Each student enrolled in the course will be required choose a contemporary topic of research interest in the field of wind energy conversion systems. Instructor will assign this project in the 12th week of classes in the semester. The student is expected to perform high quality literature search and draw conclusions about state-of-the-art and the future of the topic chosen. A technically sound research paper on the topic of choice written in the form of a conference paper (according to the IEEE PES template) is a required deliverable from each student. The template will be provided to the students or can be obtained by performing a Google® search using the phrase ‘IEEE PES template’. Each student (or group) is required to present their paper in the form of a short presentation to the class and take questions from the audience during the 16th (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 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.”
Academic honesty (contd.)

Departures from accepted norms of academic integrity will be dealt with full compliance to CSU principles published in the CSU General Catalog (see page seven, column two: http://www.catalog.colostate.edu/front/policies.aspx). The instructor may use Blackboard SafeAssign for verification of plagiarism in any work that is submitted by a student for grade in the ECE565 course. For more information on SafeAssign, see: http://www.safeassign.com/. Visit http://tilt.colostate.edu/integrity/honorpledge/ for familiarizing with the CSU Honor Pledge.