Electrical Engineering 551X
Electromechanical Wind Energy Conversion and Grid Integration (Fall 2010)

Instructor	Dr. Dionysios Aliprantis, Litton Industries Assistant Professor, ECpE
Contact	1124 Coover Hall, 294-7387, e-mail: `dali@iastate.edu`
Office hours	Monday & Wednesday 9:00–10:00 am
Classroom	1324 Howe, Monday-Wednesday-Friday 11:00–11:50 am
Web page	N/A; notes will be posted on WebCT
Revision	August 22, 2010

Learning Goals:

1. Learn fundamentals of wind energy conversion
2. Study modern electromechanical wind energy conversion topologies
3. Simulate the dynamic response of wind turbine power electronics converters using Matlab/Simulink
4. Discuss technological challenges of interconnecting wind turbines to the power system
5. Analyze the response of wind turbines to power system faults

Course Prerequisites:

- Familiarity with *power system analysis methods* at the level of one of the standard textbooks on this subject, including the ones by Bergen & Vittal, Grainger & Stevenson, Glover & Sarma, Gross, del Torro, Saadat, and Elgerd.
- Familiarity with *matrix algebra, calculus, network analysis theory* is essential.
- Familiarity with *Matlab/Simulink* is important.

Textbook:

"*Wind energy generation – modelling and control*," by O. Anaya-Lara, N. Jenkins, J. Ekanayake, P. Cartwright, and M. Hughes, 2009, Wiley.

Some other useful references: (the list is alphabetical and not exhaustive)

1. T. Ackermann, "*Wind power in power systems*," 2005, Wiley.
2. A. Bergen and V. Vittal, "*Power systems analysis*," 2000, Prentice-Hall.
3. T. Burton, D. Sharpe, N. Jenkins, and E. Bossanyi, "*Wind energy handbook*," 2001, Wiley.
4. S. Heier, "*Grid integration of wind energy conversion systems*," 2nd edition, 2006, Wiley.

5. P. C. Krause, O. Wasynczuk, and S. D. Sudhoff, "*Analysis of electric machinery and drive systems*," 2nd edition, 2002, Wiley.

6. P. Kundur, "*Power system stability and control*," 1994, McGraw-Hill.

7. P. W. Sauer and M. A. Pai, "*Power system dynamics and stability*," 2006, Stipes.

Tests: There will be two or three announced timed midterms and a final exam during the semester. The instructor reserves the right to change any midterm exam or the final exam to a take-home project. Midterm dates (see "Tentative Schedule of Lectures" on page 4) will be confirmed as the course progresses.

Homework: There will be homework assignments that will be posted on WebCT. For each assignment, it will be your responsibility to complete and hand in on time. The grade of late assignments will be multiplied by the following exponential penalty factor:

$$p = \exp\left\{-\frac{\text{delay (in days)}}{7}\right\},$$

where the delay can take decimal values. (For example, an assignment that would normally get a $10/10$ grade and that is delayed by 1.7 days will be worth only $7.84/10$.) Assignments will be collected at the beginning of class. Distance-education students should send their solutions to the instructor via email by the due date/time.

Course Grading Policy:

Homework assignments	33.33%
Midterms	33.33%
Final exam	33.34%

Letter grades will be determined by the following guidelines:

$\geq 85\%$	A
$\geq 80\%$	A−
$\geq 75\%$	B+
$\geq 70\%$	B
$\geq 65\%$	B−
$\geq 60\%$	C+
$\geq 55\%$	C
$\geq 50\%$	C−
$< 50\%$	F

Communication: Feel free to communicate with me in any way that is convenient to you (after class, during office hours, phone, email), for questions about the course material or assignments.

Special Needs: Please address any special needs or special accommodations with me at the beginning of the semester or as soon as you become aware of your needs. Those seeking accommodations based on disabilities should obtain a Student Academic Accommodation Request

(SAAR) form from the Disability Resources (DR) office (515-294-7220 or TTY 515-294-6635). DR is located on the main floor of the Student Services Building, Room 1076.

Academic Misconduct: Academic Misconduct in any form is in violation of Iowa State University *Student Disciplinary Regulations* and will not be tolerated. This includes, but is not limited to: copying or sharing answers on tests or assignments, plagiarism, and having someone else do your academic work. Depending on the act, a student could receive an F grade on the test/assignment, F grade for the course, and could be suspended or expelled from the University. See the Conduct Code at `http://www.dso.iastate.edu/ja` for more details and a full explanation of the Academic Misconduct policies.

Tentative Schedule of Lectures: (see next page)

Date	Lecture	Topic	Notes
8/23	1	Introduction to wind energy	
8/25	2	Introduction to wind energy	
8/27	3	Wind generator basic components	
8/30	4	Capturing the energy of the wind	
9/1	5	Basic aerodynamics	
9/3	6	Basic aerodynamics	
9/6	LABOR DAY HOLIDAY		
9/8	7	Basic aerodynamics	
9/10	8	Basic aerodynamics	
9/13	9	Induction generators (steady-state operation)	
9/15	10	Induction generators (steady-state operation)	
9/17	11	Reference frame theory	
9/20	12	Reference frame theory	
9/22	13	Reference frame theory	
9/24	14	Induction generators (*qd0* model)	
9/27	15	Induction generators (*qd0* model)	
9/29	16	Doubly-fed induction generators (steady-state operation)	
10/1	17	Doubly-fed induction generators (steady-state operation)	
10/4	18	Doubly-fed induction generators (steady-state operation)	
10/6	19	Permanent-magnet synchronous generators (steady-state operation)	
10/8	20	Permanent-magnet synchronous generators (steady-state operation)	
10/11	21	Permanent-magnet synchronous generators (steady-state operation)	Test #1
10/13	22	Computer simulation of electric machines' transients	
10/15	23	Computer simulation of electric machines' transients	
10/18	24	Power electronics for wind turbines	
10/20	25	Power electronics for wind turbines	
10/22	26	Power electronics for wind turbines	
10/25	27	Power electronics for wind turbines	
10/27	28	Power electronics for wind turbines	
10/29	29	Power electronics for wind turbines	
11/1	30	Control of DFIG-based wind turbines	
11/3	31	Control of DFIG-based wind turbines	
11/5	32	Control of DFIG-based wind turbines	
11/8	33	Control of PMSG-based wind turbines	
11/10	34	Control of PMSG-based wind turbines	
11/12	35	Control of PMSG-based wind turbines	Test #2
11/15	36	Rotor dynamics	
11/17	37	Rotor dynamics	
11/19	38	Impact of wind power plants on the power system	
11/22–26	THANKSGIVING BREAK		
11/29	39	Control of DFIG turbines for power system support	
12/1	40	Control of DFIG turbines for power system support	
12/3	41	Control of DFIG turbines for power system support	
12/6	42	HVDC transmission for wind power	
12/8	43	HVDC transmission for wind power	
12/10	44	HVDC transmission for wind power	
12/13–17	FINALS WEEK		