EE 599d: Wind energy conversion systems (WECS)

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| **Lecture Schedule** | | Tuesday, Thursday  6PM-7:30PM | **Course Type,**  **Semester** | Core for Power/Control/ Electronics Spring 2019 | | |
| **Credit Hours** | | Three | **Pre-requisites** | Power Electronics, Control of Electrical Machine Drives, Electric Circuits(UG). | | |
| **Instructor** | | S. A. Kamran Shah Jafri | **Contact** | [kame7970@yahoo.com](mailto:kame7970@yahoo.com)  Mobile:03363865066 | | |
| **Course Description** | | The course covers wind turbine technology, classification, costs, and grid codes for wind power integration. The control principles of wind energy systems, wind turbine components, aerodynamics. Derivation of the dynamic and steady-state models of wind generators: squirrel cage induction generators, double fed induction generators and synchronous generators. PWM schemes and operation of Grid-Connected Inverter with Voltage Oriented Control(VOC) and Reactive Power Control. Analysis of DFIG dynamic and steady state models with leading and lagging power factor operation through stator voltage oriented control (SVOC). The lecture topics are divided into 4 modules: wind generators and system configurations; power converters, control schemes, and dynamic steady-state performance of various practical wind energy systems. Associated problems with case studies, simulation models in MATLAB/Simulink software. | | | | |
| **Measurable Learning Outcomes** | **CLOs** | **Description** | | | **Domain, Level** | **PLOs, Level** |
| CLO1 | Demonstrate understanding of the basic concepts of wind turbine technology, classifications, costs, grid codes, components, aerodynamics. | | | Cognitive,  3 | PLO1,  Medium |
| CLO2 | Assess dynamic and steady-state models of wind generators, including squirrel cage induction generators, double fed induction generators and synchronous. | | | Cognitive  5 | PLO2,  High |
| CLO3 | Demonstrate understanding of the state-of-the-art PWM schemes used in the control of voltage and current source converters with an emphasis on high-power wind energy system. | | | Cognitive,  3 | PLO3,  Medium |
| CLO4 | Discuss doubly fed induction generator (DFIG) systems in the sub-synchronous and super-synchronous modes of operation by applying Stator Voltage Oriented Control. | | | Cognitive,  2 | PLO1,  Low |
| **Textbook** | | [Power Conversion and Control of Wind Energy Systems by B. Wu, Y. Lang, N. Zargari, and S. Kouro Wiley-IEEE Press,2011, ISBN: 978-0-470-59365-3](file:///C:\Users\SyedAliKamranShahJaf\Desktop\UET\books%20on%20wind%20energy\Dr.bin%20wu%20book.pdf) | | | | |
| **Reference Texts** | | 1. Alternative Energy Systems & Applications by B.K.Hodge, Wiley, 2010 ISBN 978-0-470-14250-9 2. Renewable Energy Technologies, edited by J.C.Sabonnadiere, Wiley, 2009,ISBN 978-1-84821-135-3 3. [Renewable and Efficient Electric Power Systems by Gilbert M. Masters, 2d edition, Wiley, 2004 ISBN 0-471-28060-7](file:///C:\Users\SyedAliKamranShahJaf\books%20on%20wind%20energy\Renewable%20and%20Efficient%20Electric%20Power%20Systems.pdf)  1. [Thomas Ackermann, Wind Power in Power Systems, John Wiley & Sons Ltd, 2012, ISBN: 978-0-470-97416-2](C:\\Users\\SyedAliKamranShahJaf\\books on wind energy\\Wind Power in Power.pdf) | | | | |
| **Grading Policy vis-à-vis CLO Mapping** | | * Quizzes (≥ 2) + Assignments 30% CLO1-CLO4 * Midterm 30% CLO1 * Final 40% CLO2 & CLO4 | | | | |

**Lecture Plan**

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| **Wk.** | Topics | **Readings & CLOs** |
| **1.5\*** | **Introduction**  State-of-the-art wind energy systems, wind turbine technology, wind energy conversion, fixed-speed and variable-speed wind energy systems, grid codes, power factor compensation. | **Ch. 1**  **CLO1** |
| **1.5\*** | **Fundamentals of Wind Energy Conversion System Control**  Wind turbine components, Wind turbine aerodynamics, turbine power characteristics, turbine modeling, passive and active stall controls, pitch control, tip speed ratio, maximum power point tracking schemes. | **Ch. 2**  **CLO1** |
| ***Quiz-1 will be taken in the 4th week*** | | |
| **4\*** | **Wind Generators and Modeling**  Reference frame transformation, induction generators (IG), IG dynamic and steady state models, synchronous generators (SG), SG dynamic and steady state models, transient and steady state analysis of wind generators. | **Ch. 3**  **CLO2** |
| ***Mid-term will be conducted on 8th week*** | | |
| **4\*** | **Power Converters in Wind Energy Conversion Systems**  1-phase and 3-phase AC voltage controllers, multi-channel interleaved boost converters, voltage source converters, control of grid-tied converters, reactive power control. | **Ch. 4**  **CLO3** |
| ***Quiz-2(at scheduled time)*** | | |
| **4\*** | **Doubly-Fed Induction Generator Based WECS**  System configurations, super- and sub-synchronous modes of operation, Unity Power Factor Operation of DFIG, Leading and Lagging Power Factor Operation, stator voltage oriented control (SVOC), DFIG dynamic and steady state models, and their analysis. | **Ch. 8**  **CLO4** |
| ***Final*** | | |

**\* -** Tentative