COURSE OUTLINE

Academic Year	AY2020/21	Semester	S2
Course Coordinator	Ali I Maswood		
Course Code	EE4504		
Course Title	Design of Clean Energy Systems		
Pre-requisites	Before AY2021-22 Sem2:	EE3010 Electrical Devices & Machines and EE3015 Power Systems & Conversion	
	AY2021-22 Sem2 and onwards:	EE3010 Electrical Devices & Machines and EE3015 Power Systems & Conversion or EE2005 Electrical Devices & Machines and EE3015 Power Systems & Conversion	
No of AUs	2		
Contact Hours	39 hours (13 Lecture &26 Hands on)		
Proposal Date	5 March 2020 (REF#ACC-CN-2020/06_ITN-02)		

Course Aims

The main objective of this design course is to familiarize the students with engineering design and analysis techniques for two most popular clean energy systems. The course consists of two modules namely, (i) Design of Wind Energy Systems and (ii) Design of Solar Photovoltaic Systems. As an active learner, one is expected to learn how to Develop Models of typical wind & solar circuit systems based on a given power rating. It starts from modelling of source to Converters, to some typical loads. Having developed the model, one is expected to study it for Power flow, component rating, Efficiency etc. and compare them to existing commercial systems.

Intended Learning Outcomes (ILO)

By the end of this course, you should be able to:

1) Explain the types of Renewable Energies, sources and their applications.
2) Study the nature of Renewable Energies through modeling.
3) Explain the role of power converters in changing their forms. This includes AC-DC controlled/uncontrolled converters, DC-DC converters with energy storage, DC-AC inverters with PWM technique for energy efficiency & reduced harmonics.
4) Interpret various performance parameters used to assess the success of renewable energy applications.
5) Design, implement and demonstrate a real-time renewable energy system.

Course Content

Clean and renewable energy sources. Wind energy turbines and systems. Solar photovoltaic devices and systems. System-level designs. Analytical design and analysis. Modeling and simulation. Hands-on sessions using commercial software. Comprehensive case studies on wind and solar energy systems.

Course Outline

S/N	Topic	Lecture Hours	Hands on Session
1	Design of Wind Energy Systems Operation and steady-state characteristics of different induction generators used for wind turbines a) Induction Generators& their modelling b) Doubly feed induction generators & their modelling	2	4
2	Excitation a Voltage regulation and frequency control. Voltage build-up process of a stand-alone generator.	2	4
3	Integration of wind generators into an existing grid and interfacing devices. Maximum power point tracking.	2	4
4	Simulations of stand-alone and grid-connected wind generators for both constant and variable speed operations.	1	2
5	Design of Solar Photovoltaic Systems Types and characteristics of PV cells. PV modeling techniques. Maximum power point tracking	2	4
6	Power electronic converters for PV power extraction.	2	4
7	Energy storage systems for stand-alone PV systems. Software simulation at system level. Power converters for battery charging.	2	4
	Total hours	**13**	**26**

Assessment (includes both continuous and summative assessment)

Component	Course LO Tested	Related Programme LO or Graduate Attributes	Weighting	Team/ Individual	Assessment rubrics
1. Final Examination	1,2,3,4	EAB SLO* (a), (b), (c), (d)	50%	Individual	
2. CA2: Computation Laboratory Project	1,2,3,4,5	EAB SLO* (a), (b), (c), (d), (e), (j), (l)	50%	Individual	
Total			**100%**		

* Please refer to Appendix 2 on the EAB accreditation SLOs

Mapping of Course SLOs to EAB Graduate Attributes

Course Student Learning Outcomes	Cat	EAB's 12 Graduate Attributes*											
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)
EE4504 Design of Clean Energy Systems	Major PE	●	◐	●	◐	◐					◐		◐

1. Explain the types of Renewable Energies, sources and their applications.	EAB SLO* (a), (b)
2. Study the nature of Renewable Energies through modeling.	EAB SLO* (a), (d)
3. Explain the role of power converters in changing their forms. This includes AC-DC controlled/uncontrolled converters, DC-DC converters with energy storage, DC-AC inverters with PWM technique for energy efficiency & reduced harmonics.	EAB SLO*(a), (b), (c), (d), (e), (l)
4. Interpret various performance parameters used to assess the success of renewable energy applications	EAB SLO*(a), (b), (c), (d), (e), (j), (l)
5. Design, implement and demonstrate a real-time renewable energy system.	EAB SLO*(a), (b), (c), (d), (e), (j), (l)

Legend:

●	Fully consistent (contributes to more than 75% of Student Learning Outcomes)
◐	Partially consistent (contributes to about 50% of Student Learning Outcomes)
○	Weakly consistent (contributes to about 25% of Student Learning Outcomes)
Blank	Not related to Student Learning Outcomes

Formative feedback

Examination results;

Design report (CA);

CA scores and answers through NTU Learn;

Markers' report on overall examination performance.

Learning and Teaching approach

Approach	How does this approach support students in achieving the learning outcomes?
LECTURE	Course materials covering all topics.
TUTORIAL	NA
LABORATORY(if any)	Classroom discussions and Hands-on exercises on related topics.

Reading and References

TEXTBOOKS

1. Simões Marcelo Godoy and Farret Felix A, Renewable Energy Systems – Design and Analysis with Induction Generators, 2nd Edition, CRC Press, 2007. (TJ808.S593 2007)
2. Green M A, Third Generation Photovoltaics Advanced Solar Energy Conversion, Springer, 2006. (TK8322.G797 & e-book)

REFERENCE

1. Thomas Ackemann, Wind Power in Power Systems, 2nd Edition, John Wiley, 2013. (TK1541.W763 2012)

Course Policies and Student Responsibilities

You are expected to complete all online activities and take all scheduled assignments and tests by due dates if any. You are expected to take responsibility to follow up with course notes, assignments and course related announcements. You are expected to participate in all laboratory discussions and activities.

Absenteeism: Hands on activities in laboratories make up a significant portion of your course grade. Absence from continuous assessments and laboratories without officially approved leave will result in no marks and affect your overall course grade.

Academic Integrity

Proper academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's values.

It is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. You should go to the academic integrity website for more information.

Course Instructors

Instructor	Office Location	Phone	Email
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Planned Weekly Schedule

Week	Topic	Course LO	Readings/ Activities
1	Introduction of renewable generation systems	1,2	1 Design lecture + 2 Design practical
2	Key Components of a Wind Power Conversion System & Introduction of PLECS	1,2	1 Design lecture + 2 Design practical
3	Steady-State Analysis of Power Converters	3,4	1 Design lecture + 2 Design practical

4	Modelling and Control of Power Converters	3,4	1 Design lecture + 2 Design practical
5	Analysis of Three-Phase DC/AC Inverters	3,4	1 Design lecture + 2 Design practical
6	Modelling and Control of Three-Phase DC/AC Inverters	3,4	1 Design lecture + 2 Design practical
7	Design of Three-Phase Back-to-Back AC/DC/AC Power Converters for Wind Power Generation	3,4	1 Design lecture + 2 Design practical
8	Study & Modeling of Solar panel systems (SPS)	3,4	1 Design lecture + 2 Design Practical
9	Design of DC-DC converters, MPPT circuits	3,4	1 Design lecture + 2 Design practical
10	Design of Maximum power point circuits (MPPT)	3,4	1 Design lecture + 2 Design practical
11	Integration of MPPT to SPS and Max. power Extraction	3,4	1 Design lecture + 2 Design Practical
12	Design & modeling of a Lead acid Battery	3,4	1 Design lecture + 2 Design practical
13	Integration of the entire system & Battery Charging operation Through SPS & MPPT	3,4, 5	1 Design lecture + 2 Design practical

Appendix 2: The EAB (Engineering Accreditation Board) Accreditation SLOs (Student Learning Outcomes)

a) **Engineering knowledge:** Apply the knowledge of mathematics, natural science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems
b) **Problem Analysis:** Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c) **Design/development of Solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.
d) **Investigation:** Conduct investigations of complex problems using research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
e) **Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations
f) **The engineer and Society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
g) **Environment and Sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for the sustainable development.
h) **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
i) **Individual and Team Work:** Function effectively as an individual, and as a member or leader in diverse teams and in multidisciplinary settings.
j) **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
k) **Project Management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and economic decision-making, and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
l) **Life-long Learning:** Recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.