COURSE TITLE	**CONTROL ALGORITHMS FOR PV AND WIND ENERGY SYSTEMS**
COURSE CODE	**01EE0714**
COURSE CREDITS	**3**

Objective:

1 This course gives students the skills and knowledge about a grid connected solar (PV) and Wind system with different grid synchronisation methods. It also provides knowledge on the filter topologies and MPPT systems for a grid connected system in accordance with need of grid converter control.

Course Outcomes: After completion of this course, student will be able to:

1 Interpret the grid requirements for power converter integration

2 Illustrate Grid synchronization techniques for renewable energy system

3 Compare different control techniques for grid connected system

4 Choose filters for Grid connected converters

5 Configure the power electronic interface to perform Maximum Power Point Tracking for a renewable energy source.

Pre-requisite of course: Wind and Solar, Power Electronics, Control System, Power electronics converter for renewable energy sources

Teaching and Examination Scheme

Theory Hours	Tutorial Hours	Practical Hours	ESE	IA	CSE	Viva	Term Work
3	0	0	50	30	20	0	0

Contents : Unit	Topics	Contact Hours
1	**Grid requirement for PV and WT system** Introduction, International Regulations, Response to Abnormal Grid Conditions, Power Quality, Anti Islanding requirements, Grid Code Evolution for WT system, Frequency and Voltage Deviation under Normal Operation, Active Power Control in Normal Operation, Reactive Power Control in Normal Operation, Behaviour under grid disturbances, future trends	6

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Contents : Unit	Topics	Contact Hours
2	**Grid Synchronization for Single-Phase and Three-Phase Power Converters** Grid Synchronization Techniques for Single-Phase Systems, Phase Detection Based on In-Quadrature Signals, Some PLLs Based on In-Quadrature Signal Generation, PLL based on T/4 transport delay and PLL based on inverse Park transformation, PLL based on Adaptive filter: Enhanced PLL, Second order adaptive filter, The Three-Phase Voltage Vector under Grid Faults, The Synchronous Reference Frame PLL under Unbalanced and Distorted Grid Conditions, The Decoupled Double Synchronous Reference Frame PLL (DDSRF-PLL), The double synchronous reference frame, Decoupling network, The Double Second-Order Generalized Integrator FLL (DSOGI-FLL), The structure of DSOGI-FLL and response of DSOGI-Fll, Relation between DSOGI PLL and DDSRF PLL	10
3	**Filter configurations for Grid converters** Filter Topologies, Design Considerations, Practical Examples of LCL Filters and Grid Interactions, Resonance Problem and Damping Solutions, Nonlinear Behaviour of the Filter	8
4	**MPPT Control for PV and WT system** The Dynamic Optimization Problem, Fractional Open-Circuit Voltage and Short-Circuit Current, MPPT Control Methods, The Perturb and Observe Approach, Improvements of the P&O Algorithm, The Incremental Conductance Method, MPPT Efficiency, Limitation of standard MPPT	8
5	**Grid Converter Control for Renewable Energy interface** Model of the Converter: Mathematical Model of the L-Filter Inverter, AC Voltage and DC Voltage Control, Management of the DC Link Voltage, Cascaded Control of the DC Voltage through the AC Current, Tuning Procedure of the PI Controller, PI-Based Voltage Control, Voltage Oriented Control and Direct Power Control: Synchronous Frame VOC: PQ Open-Loop Control, Synchronous Frame VOC: PQ Closed-Loop Control, Direct Power Control	10
Total Hours		**42**

Textbook :

1 Grid Converters for Photovoltaic and Wind Power systems, Remus Teodorescu, Marco Liserre, Pedro Rodriguez, A John Wiley Publication, 2011

References:

1 Power Electronics and Control Techniques for Maximum Energy Harvesting in Photovoltaic systems, Power Electronics and Control Techniques for Maximum Energy Harvesting in Photovoltaic systems, Nicola Femia, Giovanni Petrone, Giovanni Spagnuolo, Massimo Vitelli, CRC Press, Taylor and Francis Group, 2017

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References:

2 Photovoltaic Power System: Modelling, Design, and Control, Photovoltaic Power System: Modelling, Design, and Control, P Weidong Xiao, Wiley Publication, 2017

3 Modern MPPT Techniques for Photovoltaic Energy Systems, Modern MPPT Techniques for Photovoltaic Energy Systems, Ali M. Eltamaly, Almoataz Y. Abdelaziz, Springer International Publishing, 2020

4 Grid integration of solar photovoltaic systems, Grid integration of solar photovoltaic systems, Jamil, Majid, Kothari, Dwarkadas Pralhaddas, Rizwan, M,, CRC press, 2018

5 Advanced control and optimization paradigms for wind energy systems, Advanced control and optimization paradigms for wind energy systems, R. E. Precup, T. Kamal, and H. S. Zulqadar, Springer, 2019

6 Power Conversion of Renewable Energy Systems, Power Conversion of Renewable Energy Systems, Ewald F. Fuchs, Mohammad, A.S. Masoum, Springer, 2011

Suggested Theory Distribution:

The suggested theory distribution as per Bloom's taxonomy is as follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process

Distribution of Theory for course delivery					
Remember / Knowledge	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Higher order Thinking / Creative**
10.00	20.00	25.00	25.00	10.00	10.00

Instructional Method:

1 The course delivery method will depend upon the requirement of content and the needs of students. The teacher, in addition to conventional teaching methods, may also use any tools such as demonstration, role play, Quiz, brainstorming, MOOCs, etc.

2 The internal evaluation will be done on the basis of continuous evaluation of students in the laboratory and classroom.

3 Students will use supplementary resources such as online videos, NPTEL videos, e-courses, and Virtual Laboratory

Supplementary Resources:

1 https://onlinecourses.nptel.ac.in/noc22_ee71/preview

2 https://onlinecourses.nptel.ac.in/noc19_ee64/preview

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