INSTITUTE	**FACULTY OF TECHNOLOGY**
PROGRAM	**MASTER OF TECHNOLOGY in ELECTRICAL ENGINEERING**
SEMESTER	**2**
COURSE TITLE	**CONTROL OF GRID CONNECTED CONVERTERS FOR PV AND WIND SYSTEMS**
COURSE CODE	**01PE1205**
COURSE CREDITS	**4**

Objective:

1 Students will be able to design and implement control techniques for grid connected System matching with standards.

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

1 Design control technique for grid connected PV & WT converter.
2 Implement Grid synchronization technique for renewable energy system
3 Design filters for Grid connected converters.
4 Design Energy Harvesting system for renewable energy sources.
5 To Evaluate grid codes for grid connected system.

Pre-requisite of course:NA

Teaching and Examination Scheme

Theory Hours	Tutorial Hours	Practical Hours	ESE	IA	CSE	Viva	Term Work
3	0	2	50	30	20	25	25

Contents : Unit	Topics	Contact Hours
1	**Grid requirement for PV and WT system** Introduction, International Regulations, Response to Abnormal Grid Conditions,, Power Quality. 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	6

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Contents : Unit	Topics	Contact Hours
2	**Grid Synchronization for Single-Phase and Three-Phase Power Converters** Grid Synchronization for Single-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., Grid Synchronization for Three-Phase Power Converters: 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 Second- Order Generalized Integrator FLL (DSOGI-FLL)	8
3	**Introduction to control strategy of Converters with different filter configurations** Filter Topologies, Design Considerations, Practical Examples of LCL Filters and Grid Interactions,, Resonance Problem and Damping Solutions, Nonlinear Behavior of the Filter., Converter configurations, Different current Control techniques– PI control, PR control, HCC,, Model Predictive control. Power flow control methods for grid connected inverters like Voltage Oriented Control (VOC) & Direct Power Control (DPC)	12
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. Charge controller for off grid PV system	6
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, Stand-alone.	8
Total Hours		**40**

Suggested List of Experiments:

Contents : Unit	Topics	Contact Hours
1	**Experiment No - 01** To analyze the THD in six step three phase inverter.	2
2	**Experiment No - 02** To simulate grid synchronization for single phase inverter.	2

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Suggested List of Experiments:

Contents : Unit	Topics	Contact Hours
3	**Experiment No - 03** To observe the performance of three phase SRF-PLL in balanced and unbalanced grid voltage condition	2
4	**Experiment No - 04** To design LCL filter for grid connected converter.	2
5	**Experiment No - 05** To simulate current control of inverter using PI controller.	2
6	**Experiment No - 06** To simulate grid tied inverter control using hysteresis current control.	2
7	**Experiment No - 07** To obtain PV and IV curve of solar panel.	2
8	**Experiment No - 08** To Simulate the MPPT control of DC-DC converter.	2
9	**Experiment No - 09** To develop a mathematical model of L-filter inverter	2
10	**Experiment No - 10** To familiarize with grid requirements specified by IEEE 1547.	2
Total Hours		**20**

Textbook :

1 Grid Converters for Photovoltaic and Wind Power systems,, IEEE,, A John Wiley and Sons, Ltd, Publication, NA

2 Power Electronics and Control Techniques for Maximum Energy Harvesting in Photovoltaic systems,, Taylor and Francis Group., CRC Group, NA

3 Photovoltaic Power System: Modeling, Design, and Control, Weidong Xiao,, Wiley Publication., NA

References:

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

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 and evaluation					
Remember / Knowledge	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Higher order Thinking / Creative**
5.00	10.00	15.00	30.00	20.00	20.00

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Instructional Method:

1. The course delivery method will depend upon the requirement of content and need of students. The teacher in addition to conventional teaching method by black board, may also use any of 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. Practical examination will be conducted at the end of semester for evaluation of performance of students in laboratory.
4. Students will use supplementary resources such as online videos, NPTEL videos, e-courses, Virtual Laboratory

Supplementary Resources:

1. https://archive.nptel.ac.in/courses/108/107/108107143/
2. https://elearn.nptel.ac.in/shop/iit-workshops/completed/grid-connected-inverters-operation-and-control/?v=c86ee0d9d7ed

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