22EEHO208	CONTROL AND INTEGRATION OF RENEWABLE ENERGY SOURCES		SEMESTER			
PREREQUISITES		CATEGORY	PEC	Credit		3
Nil		Hours/Week	L	T	P	TH
			3	0	0	3

Course Objectives:

1. To understand electric power Generation, Transmission and Distribution
2. To study Power System Operation and Control

UNIT I	INTRODUCTION	9	0	0	9

Electric grid, Utility ideal features, Supply guarantee, power quality, Stability and cost; Importance & Effects of Renewable Energy penetration into the grid, Boundaries of the actual grid configuration, Consumption models and patterns.

UNIT II	DYNAMIC ENERGY CONVERSION TECHNOLOGIES	9	0	0	9

Introduction, types of conventional and nonconventional dynamic generation technologies, principle of operation and analysis of reciprocating engines, gas and micro turbines, hydro and wind based generation technologies

UNIT III	STATIC ENERGY CONVERSION TECHNOLOGIES	9	0	0	9

Introduction, types of conventional and nonconventional static generation technologies; Principle of operation and analysis of fuel cell, photovoltaic systems and wind generation technologies; MPPT techniques and its classifications, principle of operation and partial shading effects; Storage Technologies - batteries, fly wheels, super capacitors and ultra-capacitors.

UNIT IV	CONTROL ISSUES AND CHALLENGES	9	0	0	9

Linear and nonlinear controllers, predictive controllers and adaptive controllers, Load frequency and Voltage Control, PLL, Modulation Techniques, Control of Diesel, PV, wind and fuel cell based generators, Dimensioning of filters, Fault-ride through Capabilities.

UNIT V	INTEGRATION OF ENERGY CONVERSION TECHNOLOGIES	9	0	0	9

Introduction & importance, sizing, Optimized integrated systems, Interfacing requirements, Distributed versus Centralized Control, Grid connected Photovoltaic systems –classifications, operation, merits & demerits; Islanding Operations, stability and protection issues, load sharing, operation & control of hybrid energy systems, Solar Photovoltaic applications. IEEE & IEC Codes and standards for renewable energy grid integrations

Total (45L+0T) = 45 Periods

Text Books:

1. Renewable and Efficient Electric Power Systems, G. Masters, IEEE-John Wiley and Sons Ltd. Publishers, 2013,2nd Edition
2. Microgrids and Active Distribution Networks, S.Chowdhury, S. P. Chowdhury, P.Crossley, IET Power Electronics Series, 2012.
3. Integration and Control of Renewable Energy in Electric Power System, Ali Keyhani Mohammad Marwali, Min Dai, John Wiley publishing company, 2010, 2nd Edition.

Reference Books:

1. Solar Photovoltaic: Fundamentals, technologies & Applications, Chetan Singh Solanki, PHI Publishers, 2019, 3rd Edition.
2. Solar PV Power: Design, Manufacturing and Applications from Sand to Systems, Rabindra Kumar Satpathy, Venkateswarlu Parmuru, Academic Press, 2020.
3. Control of Power Inverters in Renewable Energy and Smart Grid Integration, Quing-Chang Zhong, IEEE-John Wiley and Sons Ltd. Publishers, 2013,1st Edition.
4. Power Conversion and Control of Wind Energy Systems, Bin Wu, Yongqiang Lang, NavidZargari, IEEE- John Wiley and Sons Ltd. Publishers,2011,1st Edition.
5. Report on “Large Scale Grid Integration of Renewable Energy Sources - Way Forward” Central Electricity Authority, GoI, 2013.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand different renewable energy sources and storage devices.	L2: Understanding
CO2	:	Model and simulate renewable energy sources.	L5: Evaluating
CO3	:	Apply various MPPT techniques for wind and solar energy generation	L3: Applying
CO4	:	Analyze and simulate control strategies for grid connected and off-grid systems	L4: Analyzing
CO5	:	Develop converters to comply with grid standards to obtain grid integration	L6: Creating

COURSE ARTICULATION MATRIX

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	2	2	2	2	3	3	1	1	2	1	2	3	3	3	3
CO2	3	2	3	3	3	3	1	1	2	1	2	1	3	3	3
CO3	3	2	3	3	3	3	1	1	1	2	1	1	3	3	3
CO4	3	2	3	3	3	3	1	2	2	2	1	1	3	3	3
CO5	3	2	3	3	3	3	1	2	2	2	2	1	3	3	3
Avg	2.8	2	2.8	2.8	3	3	1	1.4	1.8	1.6	1.6	1.4	3	3	3

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)