GUJARAT TECHNOLOGICAL UNIVERSITY

ELECTRICAL ENGINEERING (07)

POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS

SUBJECT CODE: 2740705

M.E. SEMESTER - IV

Type of course: Elective

Prerequisite: Power Electronics

Rationale: The increasing demand of the energy, rapid depletion of the conventional energy sources, and the environmental concern, have accelerated the interest in the renewable energy sources. However, energy from most of these renewable energy sources is not in the form required and needs power electronics converters to process the power and to convert the voltage/current in the appropriate form. This course is aimed to provide detailed knowledge of these renewable energy sources, need of power electronic converters, various converter topologies for different renewable sources, issues in their operation, control and integration etc.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
				Theory Marks		Practical Marks				
L	T	P	C	ESE (E)	PA (M)	ESE (V)		PA (I)		
						ESE	OEP	PA	RP	
3	2#	0	4	70	30	30	0	10	10	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1.	Energy Scenario National and International current energy scenario; Share of renewable and non-renewable energy sources	01	0
2	Photovoltaic Energy Conversion Systems Introduction to solar cell; PV cell technology; I-V and P-V curves of PV cell/modules/array; Electrical modeling of PV cell; Sun tracking and Sun tracking System (Mechanical Tracking); Maximum Power Point Tracking (Electrical Tracking); MPPT techniques; I-V and P-V curves under non-uniform conditions; PV inverter configurations; Distributed MPPT; Control of PV inverter/converter configurations; Grid connected Systems; Islanded systems; Recent development in converter configurations for PV	14	30
3	Wind Energy Conversion Systems Basics of wind energy; Components of wind turbine; Wind turbine aerodynamics; MPPT control; Modeling of wind energy system; Types of generators: induction (singly fed and doubly fed) and synchronous generators; Converters for wind energy conversion system; Fixed speed and variable speed wind energy conversion system; Control schemes for different wind energy conversion system configurations	14	30

4.	Operation and control of Distributed Energy Generators Distributed Power Generation Systems; Single-Stage Photovoltaic Systems ; Small/Medium-Sized Wind Turbine Systems; Overview of the Control Structure; Control of Power Converters for Grid-Interactive Distributed Power Generation Systems; Droop Control; Power Control in Microgrids; Control Design Parameters; Harmonic Compensation; Ancillary Feature; Voltage Support at Local Loads Level ; Reactive Power Capability; Voltage Support at Electric Power System Area: Anti-islanding; Ride-through requirements	06	15
5.	Issues, Regulations and Standards for Grid Connection Grid requirements for PV system and modern wind energy system: Issues like safety, harmonics, stability, synchronization, islanding, restoration, ride-through etc.; Recent international standards adopted by various countries or consortium	04	07
6.	Energy Storage system Introduction; The Structure of Power Storage Devices; Pumped-storage Hydroelectricity ;Compressed Air Energy Storage System; Flywheels; Battery Storage; Battery charging circuits; Hydrogen Storage; Superconducting Magnet Energy Storage; Super-capacitors; Role of Energy Storage Devices for distributed generation	04	09
7.	Others Fuel Cell: Principle, types and applications; Converters for fuel cell; Control of Fuel Cell Control System; Electric and Hybrid Vehicles; Power Electronics for EV and Hybrid vehicles; Vehicle to grid and vehicle to home system; Concept of Smart Grid, Communication, metering, issues etc.	05	09

Reference Books:

1. Remus Teodorescu, Marco Liserre, Pedro Rodriguez, "Grid Converters for Photovoltaic and Wind Power Systems", Wiley IEEE Press, Jan 2011.
2. Bin Wu, Yongqiang Lang, Navid Zargari, Samir Kouro ,"Power Conversion and Control of Wind Energy Systems", Wiley IEEE Press, July 2011.
3. Haitham Abu-Rub, Mariusz Malinowski, Kamal Al-Haddad, "Power Electronics for Renewable Energy Systems, Transportation and Industrial Applications", Wiley IEEE Press, June 2014
4. Ali Keyhani, Mohmmand N. Marwadi, Min Dai; "Integration of Green and Renewable energy in electric power system", John Wiley & sons, 2010.
5. Chetan S. Solanki; "Solar Photovoltaics: Fundamentals, Technologies & applications", Prentice Hall of India, 2009.
6. Mukund R. Patel; "Wind & Solar Power System Design, analysis & Operation", Taylor & Francis, 2006.
7. Qing-Chang Zhong, Tomas Hornik;"Control of Power Inverters in Renewable Energy and Smart Grid Integration" Wiley IEEE Press, Jan 2013.
8. M. Hashem Nahrir, Caisheng Wang; "Modeling and Control of Fuel Cells: Distributed Generation Applications", Wiley IEEE Press, 2009.
9. Frede Blaabjerg, Zhe Chen, "Power Electronics for Modern Wind Turbines", Morgan and Claypool Publishers,
10. Recent literature

Course Outcome:

1. correlate the need of renewable energy for the benefit of the society
2. demonstrate use of power converters for processing of renewable power
3. select appropriate power electronic converter for particular renewable energy source
4. design the control scheme for power converter for PV system
5. design the control scheme for power converter for Wind Energy Conversion System
6. explain the issues involved in the control and integration of renewable sources with the grid
7. demonstrate the knowhow of various energy storage techniques

List of Open Source Software/learning website:

1. MIT OPEN COURSEWARE by Massachusetts Institute of Technology
   - website: ocw.mit.edu
2. Courses available through NPTEL.
   - website : nptel.ac.in

Review Presentation (RP): The concerned faculty member shall provide the list of peer reviewed Journals and Tier-I and Tier-II Conferences relating to the subject (or relating to the area of thesis for seminar) to the students in the beginning of the semester. The same list will be uploaded on GTU website during the first two weeks of the start of the semester. Every student or a group of students shall critically study 2 papers, integrate the details and make presentation in the last two weeks of the semester. The GTU marks entry portal will allow entry of marks only after uploading of the best 3 presentations. A unique id number will be generated only after uploading the presentations. Thereafter the entry of marks will be allowed. The best 3 presentations of each college will be uploaded on GTU website.