GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: POWER ELECTRONICS FOR RENEWABLE ENERGY
(COURSE CODE:3362401)

Diploma Programme in which this course is offered	Semester in which offered
Power Electronics	Sixth

1. RATIONALE

The rapid increase in global energy consumption and the impact of greenhouse gas emissions has accelerated the transition towards greener energy sources. The need for distributed generation employing renewable energy sources such as wind, solar and bio mass has gained significant momentum. High power electronic systems, affordable high performance devices, and smart energy management principles are deemed to be an integral part of renewable, green and efficient energy systems. This course is intended to develop the competency of maintaining renewable energy equipment using power electronic devices and circuits. The purpose of power electronic interface is to regulate the voltage, frequency, and power to make energy useable as per requirement.

2. COMPETENCY

The course content should be taught and implemented with the aim to develop required skills in the students so that they are able to acquire following competency:

- **Maintain power electronic devices and circuits in renewable energy equipment.**

3. COURSE OUTCOMES (COs)

The theory should be taught and practical should be carried out in such a manner that students are able to acquire required learning outcomes in cognitive, psychomotor and affective domain to demonstrate following Course Outcomes.

i. Identify renewable energy sources for generation of power.
ii. Maintain PE devices in PV power system.
iii. Maintain PE devices in Wind power system.
iv. Maintain PE devices in power system of power generation from solid waste.
v. Maintain PE devices in hybrid power system of renewable energy.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	150
3	1	2	6	70	30	20	30	

Legends: L-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment.

5. COURSE CONTENT DETAILS

Unit	Major Learning Outcomes (In Cognitive Domain)	Topics and Sub-topics
Unit – I **Renewable Energy Power Plants**	1a. Describe impact of renewable energy generation on environment. 1b. Classify the renewable energy sources. 1c. On the map mark the wind energy and geothermal energy sites of India	1.1 Renewable energy and environment. 1.2 Types of Renewable Energy Sources
	1d. Describe the working of wave energy power plants 1e. Describe the working of underwater marine current power plants 1f. Describe the working of ocean thermal energy conversion 1g. Describe the working of geothermal power plants	1.3 Wave energy power plants 1.4 Marine current power plants 1.5 Ocean Thermal Energy Power Plants 1.6 Geothermal energy power plants
Unit– II **Power Electronics in Solar PV Systems**	2a. Differentiate between solar cell, module, array and panel. 2b. Explain the working of a solar cell with relevant graphs 2c. Describe the components and function of a home solar PV system. 2d. Describe the features required of a battery for solar PV system 2e. Compare the performance of different types of batteries used in solar PV system with typical specifications	2.1 Photo Voltaic(PV): cell, module, array and panel 2.2 Home solar PV system 2.3 Components of a home solar system 2.4 Types of batteries used in solar PV system
	2f. Describe the working of a charge converter with its typical specification. 2g. Explain the working of signal conditioner in a solar system 2h. Describe the working of an inverter with used in solar PV system with typical specifications 2i. Describe the use of power electronics in solar PV systems. 2j. Prepare the specifications of power electronic devices used in solar PV systems 2k. Explain central, string and module inverters configuration for grid connection with sketches.	2.5 Charge Controller 2.6 Signal Conditioner 2.7 Inverter 2.8 Power Electronic Devices Used In a solar PV system. 2.9 Power configuration for grid-connected PV systems: central, string and module inverters configuration.
Unit– III **Power**	3a. Describe the working of a typical large geared wind power plant	3.1 Wind energy basics: wind requirement and in windy sites

Unit	Major Learning Outcomes (In Cognitive Domain)	Topics and Sub-topics
Electronics in Large Wind Power Plants	3b. Compare the features of stall, active-stall and pitch controlled wind power plants. 3c. Differentiate between Type-A, Type-B, Type-C, Type-D, wind power plants on the basis of speed variation 3d. Distinguish between geared, direct-drive and semi-geared wind power plants on the basis if construction with sketches.	3.2 Aerodynamics of Wind power Plants: stall, active-stall and pitch control 3.3 Geared wind power plants 3.4 Direct drive wind power plants 3.5 Semi-geared or hybrid wind power plants 3.6 Type-A, Type-B, Type-C, Type-D, wind power plants
	3e. Compare the performance of the power electronic devices used in wind power plants 3f. Differentiate between Type-A, Type-B, Type-C, Type-D, wind power plants on the basis of power electronics used in them. 3g. Describe the working of a soft starter used in wind power plants 3h. Describe the working of a back-to-back converters used in wind power plant with sketches	3.7 Thyristors, IGBT, GTO, IGCT 3.8 Power electronic circuits: Soft starters, Back-to-back converters, Multi-level converters
Unit–IV **Power Electronics in Small Wind Turbines**	4a. Describe the working of a typical small geared/direct drive wind power plant. 4b. Describe the various types of aerodynamic control mechanisms	4.1 Small wind turbines: components, working, geared, direct-drive wind turbines
	4c. Justify the need of hybrid power plant system	4.2 Need for hybrid systems-range and type of hybrid power generating systems
	4d. Justify the need for a for maximum power point tracking system.	4.3 Wind-PV maximum power point tracking.
Unit-V **Power Electronics in Biomass and Micro Hydro Power Generation**	5a. Describe the features of different types of biomass suitable for power generation 5b. Explain various Incineration, Gasification, Thermal De-Polymerization, Pyrolysis, Induction Heating and Plasma arc gasification processes with block diagram. 5c. Describe the status of different types of biomass-based power generation plants and their capacities currently in India and world. 5d. Describe the power electronics related to biomass power generation 5e. Describe the power electronics related to micro hydro power generation	5.1 Gas producing process from Waste: Incineration, Gasification, Thermal De-Polymerization, Pyrolysis, Induction Heating, Plasma arc gasification 5.2 Solid Waste based power generation plants and their capacities currently in India and world. 5.3 Features of Micro Hydro power plants

6. SUGGESTED SPECIFICATION TABLE WITH HOURS and MARKS (Theory)

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Renewable Energy Power Plants	06	04	04	02	10
II	Power Electronics in Solar PV systems	12	04	08	08	20
III	Power Electronics in Large Wind Power Plants	12	04	08	08	20
IV	Power Electronics in Small Wind Power Systems	04	02	04	00	06
V	Power Electronics in Biomass and Micro Hydro Power Generation	08	02	08	04	14
	Total	**42**	**16**	**32**	**22**	**70**

Legends: R = Remember**, U** = Understand**, A=** Apply and above Level (Bloom's revised taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table

7. SUGGESTED EXERCISES/PRACTICALS

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills **(outcomes in psychomotor and affective domain)** so that students are able to acquire the competencies/programme outcomes. Following is the list of practical exercises for guidance.

Note*: Here only outcomes mainly in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of* ***Course Outcomes*** *related to affective domain. Thus over all development of* ***Programme Outcomes (****as given in a common list at the beginning of curriculum document for this programme) would be assured.*

Faculty should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

S. No.	Unit No.	Practical Exercises (Outcomes in Psychomotor Domain)	Approx. Hours Required
1	I	Assemble/dismantle a micro Pelton turbine	2
2	I	Assemble/dismantle a micro Francis turbine	2
3	I	Assemble/dismantle a micro Kaplan turbine	2
4	II	Connect solar PV panels in series and parallel to test the performance for different intensities of light	2
5	II	Trouble shoot charge controllers	2
6	II	Trouble shoot inverters used in solar PV systems	2
7	III	Test functioning of thyristors, power transistors and power	2

S. No.	Unit No.	Practical Exercises (Outcomes in Psychomotor Domain)	Approx. Hours Required
		diodes in soft starters of wind turbines	
8	III	Test functioning of IGBTs used in large wind turbines	2
9	III	Test functioning of GTOs used in large wind turbines	2
10	III	Test functioning of IGCTs used in large wind turbines	2
11	III	Troubleshoot soft starters used with large wind power plants	2
12	III	Troubleshoot back-to-back converters used with large wind power plants	4
13	IV	Test performance of small wind turbines for different wind speeds	2
14	IV	Test functioning of the power electronics used in small wind turbines	2
15	IV	Test the performance of wind solar hybrid system.	2
16	IV	Test performance of Pyrolysis process for solid waste management.	2
17	IV	Test performance of a hybrid system.	2
18	V	Test performance of induction heating process used for solid waste management.	2
19	V	Assemble/dismantle a mini biomass boiler plant	2
Total			**38**
Note: Perform any of the practical exercises from above list for total of minimum 28 hours depending upon the availability of resources so that skills matching with the most of the outcomes of every unit are included.			

8. SUGGESTED STUDENT ACTIVITIES

i. Students are suggested to take survey of different available renewable energy sources and minimum required quantity for continuous generation of power.
ii. Students are suggested to find various possible places to produce power from renewable sources at or nearby home/working/unused places.
iii. Students are suggested to make small working/non working model of renewable energy power source.

9. SPECIAL INSTRUCTIONAL STRATEGIES (if any)

i. Arrange expert lectures by engineers maintaining power electronics in renewal energy systems.
ii. Arrange visit to nearby renewal energy generation and transmission systems.
iii. Show relevant video/animations
iv. Practical exercises
v. Mini project

10. SUGGESTED LEARNING RESOURCES

A) Books

S. No.	Title of Book	Author	Publication
1.	Wind Power Technology	Earnest, Joshua	PHI Learning, New Delhi, 2014
2.	Power Electronics for Renewable and Distributed Energy Systems, A Sourcebook of Topologies, Control and Integration	Chakraborty Sudipta, Simões Marcelo G, William E. Kramer	Springer-Verlag London 2013
3.	Power electronics for modern wind turbines	Frede Blaabjerg, Zhe Chen	Morgan and Claypool Publishers, latest edition
4.	Wind power plants and projects developments	Earnest Joshua, Wizelius Tore	PHI Learning, New Delhi, 2014
5.	Municipal solid waste to Energy conversion process: Economic, Technical and renewable comparison.	Young Gary C.	Wiley, 1st edition, 2010 or latest.

B) Major Equipment/Instrument with Broad Specifications

i. Grid connected solar power system.
ii. Grid connected wind power system
iii. Grid connected hybrid power module
iv. Power analyser
v. Digital Oscilloscope.

C) Software/Learning Websites

i. http://en.wikipedia.org/wiki/Renewable_energy
ii. http://www.energies-renouvelables.org/observ-er/html/inventaire/Eng/sommaire.asp#chapitre3
iii. http://www.iea.org/aboutus/faqs/renewableenergy/
iv. http://www.altenergy.org/renewables/renewables.html
*v. www.epco.in/pdf/**Electricity_Generation**_from.pdf*
vi. http://www.alternative-energy-news.info/technology/garbage-energy/
vii. http://www.energy.ca.gov/biomass/msw.html
viii. http://en.wikipedia.org/wiki/Waste-to-energy

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. K. J. Dhimar**, I/C Head, Dept. of Power Electronics, Dr. S. and S. S. Ghandhy College of Engg. and Technology, Surat
- **Prof. S. A. Patel**, LPE, Dept. of Power Electronics, Dr. S. and S. S. Ghandhy College of Engg. and Technology, Surat

Coordinator and Faculty Members from NITTTR Bhopal

- **Prof. A.S. Walkey**, Associate Professor, Department of Electrical and Electronics Engineering
- **Dr. N.P. Patidar**, Professor, Department of Electrical and Electronics Engineering