



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: PG

Branch: Energy Engineering

Course / Subject Code : ME01075011

Course / Subject Name : Solar Photovoltaic Devices and Systems

w. e. f. Academic Year:	2024-25
Semester:	1 st Semester
Category of the Course:	PEC

Prerequisite:	Knowledge of renewable energy, basics of mechanical systems and electrical concepts
Rationale:	The course intends to provide knowledge of photovoltaic cell, photovoltaic systems and solar photovoltaic applications to graduate students.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT level
1	Explain the fundamentals / physics of solar photovoltaic cell.	Understand
2	Summarize the various types & materials of solar PV cell and generation development concept.	Understand
3	Explain the components of PV system and design on-grid and off-grid PV system.	Analyze
4	Determine the various types applications of solar PV systems.	Apply
5	Appraise the future trends and upgradation in PV systems.	Evaluate

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
L	T	PR	C	Theory		Tutorial / Practical		
				ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	Physics of PV Cell: Introduction, Optical Absorption, Semiconductor physics – atomic structure – doping – carrier concentration, Homogeneous and heterogeneous p-n junctions, PV Characteristics and maximizing PV cell performance, Junctions, Solar cells in series and parallel	6	15



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2.	<p>PV Cells: Working of Solar cell, Crystalline silicon solar cells – production of silicon wafers, Fabrication of solar cells, Thin film solar cells – why thin film solar cell?, transparent conducting oxides, III-V PV technology, Thin Film silicon technology, Organic photovoltaic, Hybrid organic-Inorganics solar cells, Third and fourth Generation Concept, Present and proposed PV cells, Different materials for crystalline and Thin film solar cell, Properties of crystalline and thin film solar cells.</p>	10	15
3.	<p>Introduction to PV Systems: Introduction, Status and prospects of PV Systems, Location issue – position of sun – sun path, PV cell – module – array, Irradiation on PV module, Shadowing, Maximum power point tracking, Types and component of PV system, Energy storage – types of battery - hydrogen storage - fuel cell, PV system load and availability, Associated electronic components, Generators – types and size – characteristics, maintenance - selection, Wiring and code compliance, Balance of system, PV System design – load profile – Meteorological effect – Design of grid and off grid PV system, PV system economy and ecology.</p>	13	30
4.	<p>Solar PV Applications: Introduction, PV powered fan – module, fan with battery backup, PV powered pumping system – system component requirement – design approach for simple pumping system, PV powered area lighting system – lightening load calculation and system.</p> <p>Stand Alone PV System: Need for the refrigeration system – specification and implementation, PV powered Remote cabin – specification and implementation, Hybrid powered residence – specification and implementation, Installation requirement – operation and maintenance, Cost consideration for the PV applications.</p> <p>Utility Interactive PV System: Introduction, Nontechnical barriers Technical consideration for connecting to Grid, Small utility interactive PV system – Array installation – PCU selection and mounting, Residential rooftop system – with AC Module – with battery, medium and large utility interactive PV system.</p>	16	40
Total		45	100

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	20	30	20	20	-



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Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Photovoltaic Systems Engineering, Roger A. Messenger and Jerry Venture, CRC Press.
2. Solar Photovoltaic: Fundamentals, Technologies and Applications, Chetan Singh Solanki, PHI learning Pvt. Ltd.
3. Solar Energy – Fundamentals, Technology and Systems, K. Jager, O. Isabella, A. H. M. Smets, R. A. C. M. M. van Swaji, M. Zeman, Delft University of Technology, 2014.
4. Thin Film Solar Cells, Kasturi Lal Chopra and Suhit Ranjan Das, Springer Science + Business Media, LLC.
5. Handbook for Solar Photovoltaic Systems, Energy market authority, Building and Construction authority.
6. Solar Photovoltaic System Modelling and Analysis, T. Mariprasath, P. Kishore and K. Kalyankumar, (River Publishers Series in Power) River Publishers, Taylor & Francis Group, 2024.
- 7.

(b) Open-source software and website:

1. <http://ocw.mit.edu/courses/energy-courses/>
2. <https://nptel.ac.in/courses/117108141/>
3. <http://www.es.e.iitb.ac.in/~chetan/PVmaterial.html>
4. <https://nptel.ac.in/courses/108105058/17>
5. <https://homerenergy.com/>
6. https://www.engineeringpassion.com/best-free-solar-pv-system-simulation-design-software/#google_vignette
7. <https://www.paksolarservices.com/free-solar-pv-calculators-design-tools-and-software.html>
8. <https://download.freownloadmanager.org/Windows-PC/PVSOL-Pro/FREE-5.5.2.639.html>

Suggested Course Practical List:

1. Identifying and measuring the parameters of a solar PV Module in the field.
2. Series and Parallel connection of PV Modules.
3. Estimating the effect of Sun tracking on energy generation by solar PV modules.
4. Efficiency measurement of standalone solar PV system.
5. Dark and Illuminated Current-Voltage characteristics of solar Cell.
6. Solar cells connected in series and in parallel.
7. Dependence of Solar cell I-V characteristics on light intensity and temperature.
8. Carrier Lifetime measurements for a solar cell.
9. Solar cell simulation using PC1D simulator.



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10. SEQUEL: Using the GUI.

List of Laboratory/Learning Resources Required:

1. Solar photovoltaic cell test rig (optional)
2. Solar PV power plant including off grid and on grid switch with testing facility (including data logger and sensors) (optional)
3. Electrical circuit conceptual learning set up (optional)
4. Solar simulator, Solar cell, Series and parallel connection of solar cell, PV Module characterization kit, Series and parallel connection of PV module, Standalone solar PV System, PC1D simulator, SEQUEL, multi meter for measurement of AC and DC voltage.

Suggested Project List:

1. Solar PV operated stand-alone system development
2. Solar PV integrated hybrid energy system development
3. Solar cell fabrication and testing
4. Solar tracking system developments
5. Energy economic managements integrating solar energy
6. Solar PV based air-conditioning systems
7. Solar PV integrated vehicle technologies
8. Solar PV developments for space technology

Suggested Activities for Students:

1. Develop small solar PV power plant and conduct performance test

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