MADANAPALLE INSTITUTE OF TECHNOLOGY SCIENCE
(AUTONOMOUS)
Course Structure and Syllabi
M.Tech. Solar Power Systems [SPS]

I YEAR - I Semester

S. No.	Course code	Course name	Theory	Lab.	Credits	I.M	E.M	M.M
1.	14SPS11T01	Basics of Solar Cell Devices	4	0	4	40	60	100
2.	14SPS11T02	Power Electronic Converters	4	0	4	40	60	100
3.	14SPS11T03	Solar PV Technology	4	0	4	40	60	100
4.	14SPS11T04	Modern Control Theory	4	0	4	40	60	100
5.	14SPS11T05	Energy Storage in Solar Power System	4	0	4	40	60	100
6.	14SPS11E1a	Elective-II 1. Solar Power Protection Systems	4	0	4	40	60	100
	14SPS11E1b	2. Control and Monitoring of Solar Power Systems						
	14SPS11E1c	3. Artificial Intelligence Techniques						
7.	14SPS11P01	Solar Photovoltaic Lab	0	3	2	40	60	100
		Contact periods/week	24	3				
		Total	**27**		**26**	**280**	**420**	**700**

I YEAR - II Semester

S. No.	Course code	Course name	Theory	Lab.	Credits	I.M	E.M	M.M
1.	14SPS12T06	HVDC & Flexible A.C. Transmission Systems	4	0	4	40	60	100
2.	14SPS12T07	Solar Power System Design Methodology	4	0	4	40	60	100
3.	14SPS12T08	Design of Utility Scale Solar Power System	4	0	4	40	60	100
4.	14SPS12T09	Smart Grid Design and Analysis	4	0	4	40	60	100
5.	14SPS12T10	Design of Building Integrated Solar Power System	4	0	4	40	60	100
6.	14SPS12E2a	1.Distributed Generation and Micro Grid	4	0	4	40	60	100
	14SPS12E2b	2.Energy Conservation and Management						
	14SPS12E2c	3.Solar Power System - LCOE And Financial Analysis						
7.	14SPS12P02	Solar Simulation Lab	0	3	2	40	60	100
		Contact periods/week	24	3				
		Total	**27**		**26**	**280**	**420**	**700**

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II YEAR (III & IV Semesters)

S. No.	Course code	Course name	Credits	I.M	E.M	M.M
1.	14EPS22S01	Seminar	2	100	-	100
2.	14EPS22D01	Project work	16	-	-	-

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M. Tech I Year - I SEMESTER (SPS)

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BASICS OF SOLAR CELL DEVICES (14SPS11T01)

Course Objectives:

- To understand the solar cell basics
- To know about different types of Solar Cells
- To become cognizant of the Solar Cell Devices operation and performance
- To obtain the knowledge on basics of the various advanced solar cells

Course Outcomes:

After Completion of this course students will be able to

- Explain Basic semiconductor physics and solar cell configuration
- Elucidate different types of solar cells
- Explain solar cell characteristics
- Describe performance limitations of each cell
- Differentiate Organic and plastic solar cell
- Explain the reliability of various solar cells in terrestrial environment

UNIT I: Solar cell basic physics

Basic semiconductor physics, solar cell configuration, Absorber Materials, collector converters, Types of interfaces, Interface electrical Transport Mechanisms, Homo and Hetero Configurations used in solar cells, Junction Formation-Localized States, Optimum band gap selection for absorber. Materials for solar cells, Homojunction Solar Cell Device Physics and Cell Configurations, Hetero-junction Solar Cell Device Physics, S-S and S-I-S Hetero-junction Cell Configurations and Performances, limits and opportunities of hetero-junction solar cells.

UNIT II: Crystalline wafer based silicon solar cells.

Basic Silicon properties, monocrystalline and polycrystalline silicon solar cell physics, characteristics, performance improvement, Thin silicon solar cells, Characterisation and diagnosis of silicon wafers and solar cell devices, High-efficiency silicon solar cell concepts.

UNIT III: Thin film technologies

Amorphous silicon solar cells - single junction solar cells, multijunction solar cells, micromorphous solar cells, characteristics, performance, limitations and opportunities. Cadmium telluride thin-film PV modules, Materials and cell concepts, Basic properties of cadmium telluride, window materials selection, contact materials selection, performance limitations, challenges and opportunities for high efficiency modules. Chalcopyrite based solar cells, absorber, windows and contacts selection methodology, solar cell performance correlation, solar cell concept, carrier transport in polycrystalline solar cells and loss mechanisms, opportunities for improvement.

UNIT IV: Multijunction Space and concentrator cells

Space solar cell requirements, GaAs and high-efficiency space cell basic physics, solar cell characteristics, difference between space and terrestrial solar cells, designing of space solar cells contacts, and active semiconductors for high efficiency. High-efficiency concentrator silicon and GaAs based Multijunction solar cells.

UNIT V: Organic and Dye sensitized cells

Organic and plastic solar cell basic physics, different types of solar cells, homo junction, bulk heterojunction and multijunction – vertical stack and parallel junction solar cells, advantages and disadvantages, limitations and reliability in terrestrial environment.

Text Books:

1. Solar Cell Device Physics, Stephen J. Fonash, 2010, Academic Press.
2. Practical Hand book of photovoltaics – Tom Markhvart and Luis Castaner, 2003, Elsevier Ltd.
3. Concentrator Photovoltaics -Luque A. L. and Andreev V.M., 2007, Springer.
4. Solar Cells and Their Applications, Partain L.D., Fraas L.M., 2010, Wiley.
5. Polymer photovoltaics, Frederk C. Krebs, 2008, SPIE Press.

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M. Tech I Year - I SEMESTER (SPS)

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POWER ELECTRONIC CONVERTERS
(14SPS11T02)

Course Objectives:

- To provide the power electronic concepts behind the different working modes of inverters so as to enable deep understanding of their operation.
- Understand different types of solar PV inverters
- To equip with required skills to derive the criteria for the design of power converters for Solar Power Systems.
- To be able to analyze and comprehend the various operating modes of different Configurations of power converters.
- To be able to design different single phase and three phase inverters.

Course Outcomes:

After Completion of this course students will be able to

- Describe the fundamental principles of basic power electronic converters
- Explain Switching Characteristics of Basic Power switches
- Describe how to calculate the voltage, current and the parameters of basic power electronic converters
- Elucidate applications of power switches in basic electronic converters
- Analyze and comprehend the various operating modes of different Configurations of power converters.
- Design & simulate different single phase and three phase inverters

UNIT I: Single Phase Inverters

Introduction of power electronics, basic principles of inverters and DC/DC converters, various types of inverters and their advantages and disadvantages, design and testing of inverters, efficiency calculation, performance analysis, Introduction to self-commutated switches : MOSFET and IGBT - Principle of operation of half and full bridge inverters – Performance parameters – Voltage control of single phase inverters using various PWM techniques – various harmonic elimination techniques – forced commutated Thyristor inverters – Design of solar PV power system.

UNIT II: Three Phase Voltage Source Inverters

180 degree and 120 degree conduction mode inverters with star and delta connected loads – voltage control of three phase inverters: single, multi pulse, sinusoidal, space vector modulation techniques – Application to drive system.

UNIT III: Current Source Inverters

Operation of six-step thyristor inverter – inverter operation modes – load – commutated inverters – Auto sequential current source inverter (ASCI) – current pulsations – comparison of current source inverter and voltage source inverters – PWM techniques for current source inverters.

UNIT IV: Multilevel Inverters and Resonant Inverters
Multilevel concept – diode clamped – flying capacitor – cascade type multilevel inverters- Comparison of multilevel inverters - application of multilevel inverters – PWM techniques for MLI – single-phase & three-phase impedance source inverters, Series and parallel resonant inverters - voltage control of resonant inverters – Class E resonant inverter – resonant DC – link inverters.

UNIT V: Solar Power Converters and Grid-Connected Solar Electronics
Different types of solar power converts, string inverter, module inverter, centralized inverter, advantages and disadvantages, failures and reliability, performance analysis, Introduction ,grid-connected electronics, grid-tie inverters commercial products, evolution of PV inverters, string inverters, micro-inverters, multi-string inverters, inverter topology, multilevel inverters and comparison, multilevel inverter motivation and operation, panel mismatch, the enphase micro inverter.

Text Books:

1. Rashid .M. H “power electronics Hand book”, Academic press, 2001.
2. Rashid M.H., “Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Third Edition, New Delhi, 2004.
3. BimalK.Bose “Modern Power Electronics and AC Drives”, Pearson Education, Second Edition, 2003.
4. P.S.Bimbra, “Power Electronics”, Khanna Publishers, Eleventh EditioSolar Photovoltaic Devices and Systems.

Reference Books:

1. Physics of Solar Energy by C. Julian Chen , Published by John Wiley & Sons, Inc., Hoboken, New Jersey.
2. S.N.Bhadra, D. Kastha, & S. Banerjee “Wind Electricaal Systems”, Oxford University Press, 2009.
3. Rai. G.D, “Non conventional energy sources”, Khanna publishes, 1993.
4. Rai. G.D,” Solar Energy Utilization”, Khanna publishes, 1993.
5. Gray, L. Johnson, “Wind energy system”, prentice hall linc, 1995.
6. Non-conventional Energy sources B.H.Khan Tata McGraw-hill Publishing Company, New Delhi.
7. Jai P.Agrawal, “Power Electronics Systems”, Pearson Education, Second Edition, 2002.
8. Ned Mohan,T.MUndeland and W.P Robbin, “Power Electronics: converters, Application and design” John Wiley and sons.Wiley India edition, 2006.
9. Philip T. krein, “Elements of Power Electronics” Oxford University Press -1998.
10. P.C. Sen, “Modern Power Electronics”, Wheeler Publishing Co, First Edition, New Delhi,1998.
11. 2009 Annual World Solar PV Industry Report from MarketBuzz.
12. Data: BP Solar SOL-GEN™ UT UTILITY-TIED SYSTEMS

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M. Tech I Year - I SEMESTER(SPS)

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SOLAR PV TECHNOLOGY
(14SPS11T03)

Course Objectives:

- To understand the wide variety of solar PV technologies existing in the PV industry
- To learn the manufacturing processes involved in Solar Cell Production
- To become cognizant of the latest technological advancements in the PV Technologies

Course Outcomes:

After Completion of this course students will be able to

- Describe the different types of Silicon Wafer/Sheet fabrications & wafering processes
- Explain about cell matrix, encapsulation, vacuum lamination
- Elucidate the Solar cell architectures
- Describe Testing & Characterization of Solar PV modules
- Analyze the Solar cell module efficiency
- Describe different methods of Manufacturing of solar photovoltaic cells

UNIT I: Silicon Wafer/Sheet Fabrication
Solar grade Silicon production, Quartz to metallurgical-grade (MG) silicon, MG silicon to semiconductor grade (SG) polysilicon, SG polysilicon to single-crystal ingot by Czochralski process, Ingot to silicon wafers, wafering processes, Requirements of monocrystalline solar (c-Si) cells, microcrystalline silicon (mc-Si) solar cells production by block-cast sheet production method, comparison between Cz-Si solar cells with mc-Si solar cells

UNIT II: Production of Silicon Solar Cell Module and Amorphous Silicon Solar Module
Silicon solar cells to Photovoltaic Module (PV) production, Cell fabrication and interconnections, Top and Bottom connections, Manufacturing process, Cell matrix, encapsulation, vacuum lamination, Post-lamination steps, Bifacial modules, Electrical and optical performance of modules, Local shading and hot spot formation, Amorphous silicon solar cell structures for single junction and multijunction, Substrate selection and preparation, top and bottom contacts selection and preparation, ARC coatings selection and fabrication, PECVD deposition process for amorphous silicon active layer deposition and Physical vapor deposition for contact formation, laser scribing for monolithic integration, lamination, junction box, automation, challenges and opportunities.

UNIT III: Cadmium Telluride and Copper Indium Gallium diselenide solar cell modules
Solar cell architectures, fabrication processes, substrate and superstrate configurations, selection of window materials, top and bottom contacts requirements and fabrication processes, lamination of solar modules, testing and characterization CIGS solar cell structure and active layers preparation, substrate – rigid, flexible and semi-rigid configurations, advantages and disadvantages of CIGS for different applications. Lamination and module processing. Solar cell module efficiency loss analysis.

UNIT IV: III-V Compound Solar Cells Manufacturing

III – V Compound Semiconductor Solar cell configurations and manufacturing processes, interconnection, module making, screening/binning, comparison of space and terrestrial solar cells, performance analysis.

UNIT V: Testing & Characterization of Solar PV modules and Future Trends in PV Technology

IEC/ASTM - Qualification testing, performance testing, performance ratio, field performance testing, failures, and reliability assessment, Modern (Third Generation) PV Technologies – Concentrating PV (CPV) – Dye Sensitized Solar Cells (DSSC) – Organic Solar Cells – Novel and Emerging Solar Cell Concepts.

Text Books:

1. Solar cell device physics by Stephen J. Fonash, Academic Press, 2010
2. Handbook of Photovoltaic Science and Engineering. Antonio Luque, Steven Hegedus, johnwiley & sons
3. Practical Handbook of Photovoltaics: Fundamentals and Applications by Augustin mcevoy, Tom Markvart, Luis Castaner, Academic Press, 2012

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M. Tech I Year - I SEMESTER(SPS)

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MODERN CONTROL THEORY
(14SPS11T04)

Course Objectives:

- To analyze dynamics of a linear system by solving system model/equation or applying domain transformation
- To analyze the system stability, controllability and observability
- To implement basic principles and techniques in designing the systems
- To formulate and solve deterministic optimal control problems in terms of performance indices
- To apply knowledge of control theory for practical implementations in engineering and network analysis

Course Outcomes:

After Completion of this course students will be able to

- Explain the dynamics of a linear system
- Analyze the stability of the system
- Describe the system design techniques
- Solve optimal control problems
- Apply the concepts to engineering problems

Unit-I

State space representation of systems. Solution to Time-Varying state equations. Evaluation of State Transition Matrix (STM) - Simulation of state equation using MATLAB/ SIMULINK program. Similarity transformation and invariance of system properties due to similarity transformations. Minimal realization of SISO, SIMO, MISO transfer functions-Discretization of a continuous time state space model-Conversion of state space model to transfer function model using Fadeeva algorithm.

Unit-II

Introduction to controllability & observability and its tests-Fundamental theorem of feedback control – Jordan Canonical form and Controllable canonical form - Pole assignment by state feedback using different techniques- Observable canonical form - Design of full order & reduced order observer – Test of controllability and observability using MATLAB.

Unit-III

Introduction to non-linear system-describing function-stability analysis using describing function-phase plane analysis.

Unit-IV

Linear Quadratic Regulator (LQR) problem and solution of algebraic Riccati equation using Eigen value and Eigen vector methods, iterative method. Controller design using output feedback- Model decomposition and decoupling by state feedback. Disturbance rejection, sensitivity and complementary sensitivity functions.

Unit-V

Introduction-Internal stability of a system-Stability in the sense of Lyapunov, asymptotic stability of linear time variant & invariant continuous systems-Popov's stability analysis-Solution of Lyapunov type equation.

Text Books:

1. K. Ogata, Modern Control Engineering, Prentice Hall, India 1997
2. T. Kailath, T., Linear Systems, Perntice Hall, Englewood Cliffs, NJ, 1980.
3. N. K. Sinha , Control Systems, New Age International, 3rd edition, 2005**.**

Reference Books:

1. Panos J Antsaklis, and Anthony N. Michel, Linear Systems, New - age international (P) LTD. Publishers, 2009.
2. John J D‟ Azzo and C. H. Houpis , "Linear Control System Analysis and Design Conventional and Modern", McGraw - Hill Book Company, 1988.
3. B.N. Dutta, Numerical Methods for linear Control Systems - , Elsevier Publication, 2007.
4. C.T.Chen Linear System Theory and Design - PHI, India.
5. Richard C. Dorf and Robert H. Bishop, Modern Control Systems, 11th Edition, Pearson
Edu, India, 2009.

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ENERGY STORAGE IN SOLAR POWER SYSTEM (14SPS11T05)

Course Objectives:

- To obtain the knowledge on concepts of Electrical Energy Storage Systems
- To learn different types of batteries and their applications
- To become cognizant on Alternate Energy Storage Methods
- To understand the concepts of Fuel cells

Course Outcomes:

After Completion of this course students will be able to

- Explain Arrhenius theory
- Explain the basic difference between Lead Acid Battery, Lithium-Ion Battery & Nickel Cadmium Battery
- Explain Alternate Energy Storage Systems
- Explain about working principle & construction of Fuel cells and their types
- Differentiate between a battery and fuel cell
- Explain Types of fuel cells and their relative merits and demerits.

UNIT I: Electrochemistry

Fundamentals of Electrochemistry: Arrhenius theory, Electrochemical cells, Electrodes and Electrode Potentials (EMF measurement, Nernst equation, Standard electrode potential) and Numerical problems. Difference between primary and secondary batteries.

UNIT II: Electrical Energy Storage

Fundamental & Principle concepts of batteries. Measuring of battery performance - charging and discharging, storage density, energy density, and safety issues. Types of batteries – Lead Acid, Nickel – Cadmium, Zinc Manganese dioxide and modern batteries for example (i) zinc-Air, (ii) Nickel Hydride, (iii) Lithium Battery.

UNIT III: Lead Acid Battery and Lithium-Ion Battery

Lead acid battery types, chemical reaction, charging and discharging characteristics, charging and discharging methods, advantages and disadvantages. Define standard parameters rechargeable batteries i.e., battery terminal voltage, state of charge, depth of discharge, memory effect, self discharge and sulphation etc., Lithium-ion battery, chemical reaction, charging and discharging characteristics, charging and discharging methods, advantages and disadvantages. Lithium metal hydride battery, chemical reaction, charging and discharging characteristics, charging and discharging methods, advantages and disadvantages.

UNIT IV: Nickel Cadmium Battery and Applications & engineering of Battery

Nickel cadmium battery, chemical reaction, charging and discharging characteristics, charging and discharging methods, advantages and disadvantages, Applications of different batteries, design and engineering of parallel and series connected batteries, aircraft/space Batteries, Automotive batteries, UPS batteries, Railway batteries.

UNIT V: Alternate Energy Storage Technologies, Fuel cells and their types

Flywheel, Super capacitors, Principles & Methods – Applications, Compressed air Energy storage, Concept of Hybrid Storage – Applications, Differences between battery and fuel cell. History – principle - working - thermodynamics and kinetics of fuel cell process – performance evaluation of fuel cell – comparison on battery Vs fuel cell. Types of fuel cells – AFC, PAFC, SOFC, MCFC, DMFC, PEMFC and BFC – relative merits and demerits. Fuel cell usage for domestic power systems, large scale power generation, Automobile, Space, Economic and environmental analysis on usage of Hydrogen and Fuel cell, Future trends in fuel cells.

Text Books:

1. Viswanathan, B and M Aulice Scibioh, Fuel Cells – Principles and Applications, Universities Press (2006)
2. Rebecca L. and Busby, Hydrogen and Fuel Cells: A Comprehensive Guide, Penn Well Corporation, Oklahoma (2005
3. Bent Sorensen (Sorensen), Hydrogen and Fuel Cells: Emerging Technologies and Applications, Elsevier, UK (2005)
4. Kordesch, K and G.Simader, Fuel Cell and Their Applications, Wiley-Vch, Germany (1996)
5. Hart, A.B and G.J.Womack, Fuel Cells: Theory and Application, Prentice Hall, NewYork Ltd., London (1989)
6. Jeremy Rifkin, The Hydrogen Economy, Penguin Group, USA (2002).
7. Newman, John, and Karen E. Thomas-Alyea. Electrochemical Systems. 5th ed. John Wiley & Sons, 2009.
8. Fuel cell fundamentals by Ryan. P and O. Hayre. John Wiley & Sons, 2006.

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M. Tech I Year - I SEMESTER(SPS)
(Elective – I)

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SOLAR POWER PROTECTION SYSTEMS
(14SPS11E1a)

Course Objectives:

- To obtain the fundamental concepts of surge protection in solar power system
- To learn about PV system over current protection of solar system
- To understand various faults of solar power system
- To know about protective devices used in solar power system

Course Outcomes:

Upon completion of the course, students will be able to:

- Explain surge protection, surge protecting devices and their methods in solar power systems
- Describe fuse links for PV String protection and fuse rating for PV Applications
- Describe the Lightning Protection methodology in Buildings
- Calculate total energy usage in buildings
- Design Circuit protection systems
- Analyze the Line-Line Fault for photovoltaic power systems
- Detect Ground Faults and to design ground fault Protection systems

UNIT I: Surge Protection of solar power system
Introduction, overview of surge protection in solar systems - air terminals, bonding and down conductors, earthing, DC surge protective devices and AC protective devices.

UNIT II: Photovoltaic System Over current Protection of solar system
Introduction, PV power protection systems, Over current protection of solar PV power system, Selective fuse links for PV String protection, PV fuse selection flow chart, Fuse rating for PV Applications.

UNIT III: Lightning Protection of solar system in Buildings
Study methodology, description of the building BEFORE refurbishment Methods of construction, Fittings, description of the building AFTER refurbishment Methods of construction Fittings, Climate data, The building's geometry and zoning, Opaque envelope components, lazing, Shading devices, Internal gain from building occupants, Internal gain from devices and equipment, Internal gain from lighting. Total energy usage, Comparison of measured and modeled energy, usage for lighting.

UNIT IV: Circuit protection design and Line-Line Fault analysis for photovoltaic power systems
Introduction, Circuit design at the Cutting edge, basic circuit protective needs, DC vs AC Circuits protections and Other PV system circuit protection issues, Introduction, Definition of Line-Line faults, causes of Line-Line faults, typical PV system and code requirements related to fuses, Line-line Fault Analysis in PV Arrays.

UNIT V: Ground Fault Protection Photovoltaic Systems
Early detection and advanced notification, ungrounded (isolated) arrays Detecting ground faults on arrays Large scale arrays, ungrounded (isolated) arrays Detecting ground faults on arrays 100 kW or less, Grounded arrays Detecting ground faults at the inverter Inverters 10 kW or less, Grounded arrays detecting ground faults at the inverter Inverters greater than 10 kW, Grounded (non-isolated) arrays, grounded (non-isolated) arrays Detecting ground faults at the master combiner Multi-channel monitoring, Detecting ground faults at the combiner box individual monitoring, Ungrounded (isolated) arrays, Communication solutions Ethernet and Mod bus integration Ground fault location.

Text Books:

1. T.S.Madhava Rao, "Power system Protection static relay", Tata McGraw Hill Publishing company limited , second edition,1989
2. Badri Ram and D.N.Vishwakarma, " Power system Protection and Switchgear ", Tata McGraw Hill Publication company limited First Edition -1995
3. Photovoltaic System Over current Protection by cooper bussmann

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M. Tech I Year - I SEMESTER(SPS)
(Elective-I)

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4	0	4

CONTROL AND MONITORING OF SOLAR POWER SYSTEMS
(14SPS11E1b)

Course Objectives:

- To understand the basic control actions and characteristics of different types of controllers.
- To understand the characteristics and mathematical modelling of final control elements.
- To learn about the operation of control systems involved in solar energy systems.
- To understand the concepts of embedded systems.

Course Outcomes:

After Completion of this course students will be able to

- Describe the characteristics of different types of controllers
- Do mathematical modeling for final control elements
- Explain I/P, P/I converters
- Describe about SCADA and Distribution control systems
- Explain IVR system, and GPS receivers.
- Use tools like MATLAB for analysis and simulation for transient and steady state response
- Analyze the current Trends in instrumentation using LABVIEW

UNIT I: Proportional, Integral & Derivative (PID) controllers and their selection
Introduction to Proportional, Integral and Derivative (PID) controllers. Characteristics - cascade and feedback - controllers design - feedback compensation. Response of controllers, Pneumatic and Electronic realization of Controllers. Selection of a controller - I/P, P/I converters-Need for process control and controller tuning-Evaluation criteria.

UNIT II: SCADA, Embedded System and its applications
Introduction of SCADA and Distribution control systems, implementation of control systems. Importance and types of graphical output - matrix operations, integration, Performance analysis, error monitoring, Introduction and requirement of embedded system - challenges, issues and trends in embedded software development system. Design cycle in development phase. Uses of emulator and in-circuit emulator, Application of embedded system - control system and industrial automation, handheld computer, IVR system, and GPS receivers.

UNIT III: Control Strategies
Advanced control of solar plants. Basic control schematics, Basic structures of adaptive control, Model-based predictive control strategies.

UNIT IV: LABVIEW
Frequency domain control and robust optimal control, Heuristic fuzzy logic control, Introduction to LABVIEW, current Trends in instrumentation using LABVIEW.

UNIT V: Transient and Steady State Response of SPS
Solar power system - transient and steady state response - simulation of the system using MATLAB.

Text Books:

1. Johnson G.C. et al. Control System Design, Pearson, 2003.
2. Velten K. Mathematical Modelling and Simulation, Wiley-VCH, 2009.
3. Camacho E.F. et al. Advanced Control of Solar Plants, Springer,1997
4. Palm W.J. Introduction to MATLAB 7. 0 for Engineers, Tata McGraw-Hill, 2004
5. Meyer W.J. Concepts of Mathematical Modelling, Dover Publ., 2004
6. Dym C.L. Principles of Mathematical Modelling, Elsevier, 2004.

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M. Tech I Year – I SEMESTER (SPS)
(Elective – I)

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ARTIFICIAL INTELLIGENCE TECHNIQUES
(14SPS11E1c)

Course Objectives:

- To gain the knowledge of Artificial Neural Networks
- To design the Single Layer and Multilayer Feed Forward Networks for different engineering applications.
- To impart the basics Fuzzy sets and Fuzzy Logic system components
- To gain the basic knowledge on Genetic Algorithms.
- To analyze & design fuzzy logic controller & genetic algorithm for electrical engineering problems.

Course Outcomes:

After Completion of this course students will be able to

- Explain the Artificial Neural Networks
- Ability to design single layer and multilayer neural networks
- Analyze self-organizing Course networks and adaptive resonance theory
- Solve economic load dispatch problems using genetic algorithms
- Apply the fuzzy sets to engineering problems

Unit – I: Introduction to Neural Networks
Introduction, Humans and Computers, Organization of the Brain, Biological Neuron, Biological and Artificial Neuron Models-architectures-Course process-Course methods.

Unit- II: Single & Multilayer Feed Forward Neural Networks
Introduction, Perceptron Models-Training Algorithms-Perceptron Convergence theorem, Limitations of the Perceptron Model- Generalized Delta Rule, Derivation of Back propagation (BP) -Training, Summary of Back propagation Algorithm, Course Difficulties and Improvements- Architecture of Hopfield Network-ANN applications to power engineering-load forecasting-load flows.

Unit-III: **Self-Organizing Maps (SOM) and Adaptive Resonance Theory (ART)**
Introduction, Competitive Course, Vector Quantization, Self-Organized Course Networks- Kohonen Networks, Training Algorithms, Linear Vector Quantization, Stability- Plasticity Dilemma, Feed forward competition-ART1, ART2.

Unit-IV: Genetic Algorithms
Introduction-encoding-fitness function-reproduction operators, genetic modeling-genetic operators-cross over and mutation-generational cycle-convergence of genetic algorithm-Genetic application-economic load dispatch.

Unit-V: Sets and Fuzzy Sets Fuzzy Logic Systems Components

Introduction to classical sets - properties, Operations and relations-Fuzzy sets, Membership, Uncertainty, Operations, properties, fuzzy relations, cardinalities, membership functions-Fuzzification, Membership value assignment, development of rule base and decision making system, Defuzzification to crisp sets, Defuzzification methods-Fuzzy application-speed control of dc motor.

Text Books:

1. Principles of – Soft Computing by S. N. Sivanandam and S. N. Deepa, Wiley India Edition.
2. Neural Networks, Fuzzy logic, Genetic algorithms: synthesis and applications by Rajasekharan and Pai – PHI Publications.
3. Neural networks by Satish Kumar , TMH, 2004.
4. Neuro Fuzzy and Soft Computing by J. S. R. Jang, C. T. Sun and E. Mizutani, Pearson Education.

Reference Books:

1. Neural Networks – James A Freeman and Davis Skapura, Pearson Education, 2002.
2. Neural Networks – Simon Hakins, Pearson Education
3. Fuzzy Logic with Engineering Applications by T. J. Ross, 2nd Edition , Wiley India Edition.
4. Neural Networks and Fuzzy Logic System by Bart Kosko, PHI Publications.
5. Genetic Algorithms by D. E. Goldberg, Addison – Wisley, 1999.

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M. Tech I Year - I SEMESTER (SPS)

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SOLAR PHOTOVOLTAIC LAB
(14SPS11P01)

Course Objectives:

- To obtain a practical knowledge and hands-on-experience on SPS by working on Photovoltaic panels, Sun Tracking System, Solar inverters.
- To obtain a fundamental knowledge on Sun Tracking System.
- To understand different characteristics of Solar Cells, Batteries, DC-DC converters, DC Motor & Inverters.
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Course Outcomes:

After Completion of this course students will be able to

- Analyze the Solar Cell characteristics for MonoCrystalline & Thin-film Solar Modules
- Calculate the power, efficiency & fill factor of solar cells
- Appreciate the Sun Tracking System and Maximum peak power tracking of Solar Panel
- Analyze the characteristics of DC motor when driven by Photovoltaic panel
- Finding methods for Charging and discharging battery to analyze the characteristics of it
- Realize the effect of shadow on solar PV panel and effect of surrounding temperature on PV panel

List of Experiments:

1. Solar cell I –V characteristics and calculation of power, efficiency and fill factor
2. Study of temperature and solar intensity dependent of solar cell characteristics.
3. Series-parallel Connection of solar panels and effects of Shading.
4. Study of Sun Tracking system.
5. Study of Characteristics of DC motor when driven by Photovoltaic panel.
6. Study of Battery charge controller
7. Fuel cell characteristics experiment.
8. Study the solar inverter characteristics
9. Charging and discharging characteristics of a battery
10. Study of DC-DC converter characteristics for solar system
11. Study of Effect of tilt angle on solar PV panel
12. Comparison of Solar panel characteristics (MonoCrystalline Solar Module vs. Thin-film Solar Module)
13. Study of Maximum peak power tracking of Solar Panel
14. Effect of shadow on solar PV panel
15. Study of Effect of surrounding temperature on PV panel

I YEAR - II SEMESTER

MADANAPALLE INSTITUTE OF TECHNOLOGY SCIENCE
(AUTONOMOUS)

M. Tech. I Year II SEMESTER(SPS)

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HVDC & FLEXIBLE A.C. TRANSMISSION SYSTEMS
(14SPS12T06)

Course Objectives:

- To understand the operating principles of power semiconductor devices.
- To analyze the operation of shunt and series compensators.
- To impart knowledge on application of shunt and series compensators to improve AC power transmission.
- To understand the configuration and working of HVDC & Ac systems
- This impart the idea about modern trends in HVDC Transmission and its application
- To analyze harmonics and to understand the different protection schemes of HVDC System

Course Outcomes:

After Completion of this course students will be able to

- Review the HVDC transmission system
- Design the HVDC converters
- Identify the suitable methods to review and reduce the harmonics in HVDC system
- Analyze the reactive power compensation in AC transmission systems
- Analyze suitable compensation for AC transmission systems
- Apply the concepts to electrical power transmission systems

Unit-I: DC Power Transmission Technology
Introduction-comparison of AC and DC transmission-application of DC transmission description of DC transmission system-planning for HVDC transmission-modern trends in DC transmission, Different configuration of HVDC scheme.

Unit-II: Analysis of HVDC Converters
Pulse number-choice of converter configuration-simplified analysis of Graetz circuit converter bridge characteristics – characteristics of a twelve pulse converter, Different faults occurred in converter, Protection against overvoltage, over current.

Unit-III: HVDC System Control
General principles of DC link control-converter control characteristics –system control hierarchy – firing angle control-current and extinction angle control-starting and stopping of DC link – power control-higher level controllers – telecommunication requirements. Harmonics and Filters: Introduction-generation of harmonics-design of AC filters-DC filters-carrier.

Unit-IV: Series Compensation Technique
Basic concepts of reactive power compensation, Types of compensation, Static VAR compensators, Resonance damper, Thyristor controlled series capacitor (TCSC), Static condenser, Phase angle regulator, and other controllers. Sub-Synchronous resonance, Tensional interaction, Modeling and control of Thyristorised controlled series compensators. Static VAR Compensation - Basic concepts, Thyristor

controlled reactor (TCR), Thyristors switched reactor (TSR), Thyristor switched capacitor (TSC), saturated reactor (SR), and fixed capacitor (FC).

Unit-V: Shunt Compensation Technique

Variable structure FACTS controllers for Power system transient stability, Non-linear variable structure control, Unified power flow, Unified Power Flow Control - Introduction, Implementation of power flow control using conventional thyristors, concept, Implementation of unified power flow controller. Basics of STATCOM, its applications.

Text Book:

1. "Understanding FACTS Devices" N.G. Hingorani and L. Guygi. IEEE Press Publications 2000.
2. Kimbark, E.W., Direct current transmission-Vol.1', Wiley Interscience, New York, 1971
3. Arrilaga, J., `High Voltage Direct current transmission', Peter PereginverLtd. London, UK.,1983
4. Padiyar, K.R., `HVDC Transmission system', Wiley Eastern Limited., New Delhi, 1992

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M. Tech I Year - II SEMESTER(SPS)

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SOLAR POWER SYSTEM DESIGN METHODOLOGY
(14SPS12T07)

Course Objectives:

- To learn various SPS Components
- To understand SPS Design Considerations
- To learn the concepts of Standalone Solar Power System
- To obtain an extensive knowledge on Large-Scale Solar Power System Construction - Troubleshooting Procedures
- To learn about Hazards that occur in SPS and Preventive Procedures
- To become cognizant and to obtain an extensive knowledge on Concentrator Photovoltaic Systems

Course Outcomes:

After Completion of this course students will be able to

- Recognize & Explain various SPS Components
- Explain Solar-Tracking Systems
- Estimate the Project Preliminary Cost, System Sizing Estimates
- Prepare modeling and simulation of Solar Power System
- To analyze, design & verify for Standalone Solar Power System
- Describe the Solar Power System Hazards and Prevention.

UNIT I: Solar Power System Technologies and Solar Photovoltaic Power System Components
Introduction, Solar power system, Overview of Solar Power System Applications, Introduction to solar PV modules, junction boxes, combiners, wires and cables, Inverters, Storage Battery Technologies, Lightning Protection, Central Monitoring and Logging System, Ground-Mount PV Module Installation and Support Structures, Roof-Mount Installations, Solar-Tracking Systems.

UNIT II: Photovoltaic Power System Feasibility Study and
Feasibility Study, Site Survey, Solar Power System Preliminary Design Considerations, Meteorological Data, Structural Design Considerations. Project Preliminary Cost Estimate, Energy Cost Factors, Solar Power System Sizing Estimates, Preparing the Feasibility Study Report, Example of a Solar Feasibility Study Report.

UNIT III: Solar Power System Design Considerations and Standalone Solar Power System
Introduction, Solar Power System Components and Materials Selection, Solar Power System Configuration and Classifications, Storage Battery Technologies Selection, Solar Power System Wiring, Entrance Service Considerations for Grid-Connected Solar Power Systems, Photovoltaic Design Guidelines, Basics of standalone solar power plant, loads estimation (day and night), sizing the power system, sizing the solar array, inverter, battery, cables and other power system components, modeling and simulation of system, performance analysis, and verification of design, costing and Levelized cost estimation. Building integrated and building attached solar power systems.

UNIT IV: Large-Scale Solar Power System Construction and Safety Procedures
Introduction, Study and Evaluation of site, feasibility study, Engineering Plans and Documents, Project Management and the Responsibilities , Construction of system, Field Performance Test and Final Acceptance and Commissioning Procedures, Troubleshooting Procedures, Overview of Solar Power System Safety Hazards, Solar Power System Loss analysis and Prevention.

UNIT V: Concentrator Photovoltaic Systems
Introduction, Concentrator Photovoltaic Technologies, Advantages of CPV Compared to Conventional PV Technologies , Concentrator Design for Passively Cooled Modules , Recent Advances in CPV Technologies, Amonix CPV Solar System, Concentrix FLATCON CPV Technology, SolFocus Concentrator Photovoltaic Technology, CPV Technology and Environmental Sustainability.

Text Books:

1. Gevorkian, Peter, “Alternative Energy Systems in Building Design”, McGraw-Hill, New York, 2010.
2. Gevorkian, Peter, “Solar Power in Building Design”, McGraw-Hill, New York, 2008.

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M. Tech I Year - II SEMESTER(SPS)

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DESIGN OF UTILITY SCALE SOLAR POWER SYSTEM (14SPS12T08)

Course Objectives:

- To obtain an overview of various project phases
- To become cognizant on Solar Power Plant project designing & documentation
- To learn about Solar Power Plant Construction
- To understand the requirements of SCADA
- To become cognizant on Solar Power plant commissioning, Operation and Maintenance

Course Outcomes:

After Completion of this course students will be able to

- Explain Solar PV power plant Mounting and Tracking Systems
- Assess the size, length & cost of the cables
- Design, Develop, Commission and Operate the Solar Power Plant
- Test the Grid connection,
- Preparation of documentation
- Identify the schedule/preventive maintenance, unscheduled maintenance
- Describe the requirements of SCADA

UNIT I: Solar PV Technology Overview and Solar Resource Assessment
Solar PV technology, Overview of Ground Mounted PV Power Plant, Solar PV Modules, solar PV power plant Mounting and Tracking Systems, cables and wire harness, Inverters, Quantifying Plant Performance, Quantifying the solar Resource, Solar Resource Assessment, Variability in Solar Irradiation, PV system software tools and solar resource measurement tools.

UNIT II: Project Development and Energy Yield Assessment
Overview of various project phases, concept study, prefeasibility study, feasibility study, development and detailed design, solar power plant performance modeling, energy yield predictions, identifying the uncertainty of energy yield predictions.

UNIT III: Solar Power Plant Design and Construction
Solar power plant technology selection, tradeoffs of solar modules, inverters, mounting system, cables and wires, lay outing the solar power plant, electrical design, infrastructure requirements, site security, monitoring and forecasting, optimizing the solar power plant design, Reliability prediction, project design documentation, Detailed project construction document preparation, interface management, programme and scheduling, supply chain management, cost management, contractor warranties and guarantees, Quality management, identifying various construction issues.

UNIT IV: SCADA and Control Components Unit
SCADA requirements – sensors, software – real and remote, monitoring and controls, tools and kits for operation and maintenance- SCADA implementation, distributed controls systems.

UNIT V: Solar Power Plant Commissioning, Operation and Maintenance
Solar power plant and substation performance testing, pre-connection acceptance testing, Grid connection testing and connection, post connection acceptance testing, provisional acceptance testing, preparation of documentation, acceptance testing, solar power plant PLF testing, performance ratio testing, verification of design and prediction performance, Identifying the schedule/preventive maintenance, unscheduled maintenance, performance loss analysis for unscheduled shutdown, identifying the spares, performance monitoring, evaluation and optimization, details of contracts, preparation of operation and maintenance manuals, Failure modes effect criticality analysis (FEMCA).

Text Books:
1. Large-Scale Solar Power System Design (GreenSource Books): An Engineering Guide for Grid-Connected Solar Power Generation Peter Gevorkian McGraw Hill Professional, 22-Apr-2011 - Technology & Engineering - 704 pages
2. Solar Photovoltaic Design for Residential, Commercial and Utility Systems By Steven Magee 15-Feb-2010 - Technology & Engineering - 92 pages
3. Wind and Solar Power Systems: Design, Analysis, and Operation, Second Edition By Mukund R. Patel
4. Utility Scale Solar Power Plants A Guide For Developers and Investors, Anita Marangoly George Director Infrastructure & Natural Resource, Asia
5. Photovoltaic systems engineering second edition by roger a. messenger jerry ventre
6. Scaling Up for Commercial PV Systems solar weekly By John Berdner
7. Array to Inverter Matching Mastering Manual Design Calculations solar weekly By John Berdner

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M. Tech I Year - II SEMESTER(SPS)

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SMART GRID DESIGN AND ANALYSIS
(14SPS12T09)

Course Objectives:

1. To know the basic concepts of Smart Grid, Micro-Grid; Design and Analysis
2. To learn about Wide Area Monitoring Systems, Smart Meters
3. To obtain a brief idea on different Renewable Energy Sources
4. To learn about Interoperability, Standards and Cyber Security

Course Outcomes:

After Completion of this course students will be able to

- Differentiate grid & smart grid
- Identify the difference between various measuring instruments and their applications
- Obtain enough knowledge on various Renewable energy resources
- Design and analyze the micro grid system
- Realize the Environmental impacts

UNIT I: Introduction to Smart Grid
Comparison between existing grid and smart grid; Objectives; Benefits; Challenges; Basic structure and functions of components.

UNIT II: Communications, Measurement and Smart Meters
Latest technologies; Wide Area Monitoring Systems (WAMS), Phasor Measurement UNITs (PMU), Smart Meters, Smart Appliances, and Advanced Metering Infrastructure (AMI); GIS and Google Mapping Tools; Multi agent Systems Technology.

UNIT III: Micro-grid and Renewable Energy & Storage
Concept of micro-grid; design and analysis; distributed generation; distributed automation, Renewable energy resources and options for smart grid including solar energy, wind energy, fuel cell, biomass etc; Penetration and variability; Demand Response; Electric vehicles and plug-in hybrid; Battery energy storage systems.

UNIT IV: Interoperability, Standards and Cyber Security
State-of-the-art, Benefits, Challenges, Risks.

UNIT V: Analysis Tools, Application Examples and their trends
Load flow studies; Static security assessment; State estimation and stability assessment; Reliability assessment; Decision support tools; Advanced optimization and control; Environmental impacts; Pathway for designing smart grid, Demonstration projects; Test beds and benchmark systems; Future trends; Research, education and training.

Text Books:

1. James Momoh, "Smart Grid: Fundamentals of design and analysis", John Wiley & sons Inc, IEEE press 2012.
2. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", John Wiley & sons inc, 2012.
3. Fereidoon P. Sioshansi, "Smart Grid: Integrating Renewable, Distributed & Efficient Energy", Academic Press, 2012.
4. Clark W.Gellings, "The smart grid: Enabling

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M. Tech I Year - II SEMESTER (SPS)

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DESIGN OF BUILDING INTEGRATED SOLAR POWER SYSTEMS (14SPS12T10)

Course Objectives:

- To obtain Basic knowledge on Integrated Photovoltaics, BIPV material
- To become familiar with BIPV System Design, BIPV products testing and project analysis
- To understand BIPV modeling and simulation tools

Course Outcomes:

After Completion of this course students will be able to

- Explain the basic concepts of Integrated Photovoltaics
- Identify the BIPV material
- Modelling of BIPV components and system
- Analyze the cases studies

UNIT I: Basics of Building Integrated Photovoltaics
BIPV/BAPV basic function and aesthetics, BIPV solar modules, codes and standards, procedures, different types of BIPV power systems – flat roof, pitched roof, sloped roof, facades, shingles, canopies and carports.

UNIT II: BIPV materials and system design
BIPV solar modules, mounting structure, wiring and cables, inverters, meters, DC connects and disconnects, combiners, distribution boxes, codes and standards for various BIPV applications, Site Solar insolation, Shading Analysis, tilt and orientation, temperature effect and ventilation, load requirements, Loss analysis, selection of BIPV components, sizing the system, energy yield estimates, best practices for design of BIPV system.

UNIT III: Engineering and Integration of BIPV systems
BIPV system engineering for slope roofs, plain roofs, shading system, Rain screen systems, stick system curtain walls, unitized curtain walls, facades, double skin facades, windows, Atria and canopies, residential, refurbishment, commercial, residential, institutional BIPVs.

Unit IV: BIPV Project Implementation and Product Testing
Preparation of project feasibility, techno-economic analysis, procurement of components, installation, operation and maintenance, Introduction to IEC and NEC standards, test procedures, qualification testing, acceptance testing, performance testing, Quality controls and safety procedures.

UNIT V: BIPV project analysis and BIPV modeling and simulation tools
Feasibility Study, Site Survey, Solar Power System Preliminary Design Considerations, Meteorological Data, Structural Design Considerations, Project Preliminary Cost Estimate, Energy Cost Factors, Solar Power System Sizing Estimates, Preparing the Feasibility Study Report, Example of a Solar Feasibility Study Report, Introduction of BIPV Architectural Design Tool, modeling of BIPV components and system, performance analysis and comparison, verification of design, analysis of case studies.

Text Books:

1. Solar Power in Building Design: The Engineer's Complete Design Resource , **ISBN:** 97800714856, Peter Gevorkian, McGraw-Hill Professional publication.
2. Large-Scale Solar Power System Design: An Engineering Guide for Grid-Connected Solar Power Generation, **ISBN:** 9780071763271, Peter Gevorkian, 2011 The McGraw-Hill Companies, Inc.
3. Building integrated photovoltaics - a handbook, Simon Roberts & Nicolo Guariento, Birkhauser Verlag AG, 2009.
4. Sustainable Energy Systems in Architectural Design – McGraw-Hill ISBN 0-07-146982-6
5. Sustainable Energy systems Engineering - McGraw-Hill ISBN 0-07-14359-9
6. Solar Power in Building Design – McGraw-Hill ISBN 0-07-148563-5
7. Alternative Energy Systems in Building Design. McGraw-Hill ISBN 0-07-146982-1

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M. Tech I Year - II SEMESTER(SPS)
(Elective – II)

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DISTRIBUTED GENERATION AND MICRO GRID
(14SPS12E2a)

Course Objectives:

- To illustrate the concept of distributed generation
- To analyze the impact of grid integration
- To study concept of Micro-grid and its configuration

Course Outcomes:

After Completion of this course students will be able to

- Explain about fuel Cells, micro-turbines, biomass, and tidal sources
- Identify DG installation classes
- Define impact of grid integration with NCE sources on existing power system
- Review the distributed generation
- Differentiate between islanding and anti-islanding schemes
- Analyze the stability and power quality in micro-grid
- Develop the micro-grid communication infrastructure

Unit-I: Distributed Generation (DG) and its installation
Conventional power generation: advantages and disadvantages, Energy crises, Non-conventional energy (NCE) resources: review of Solar PV, Wind Energy systems, Fuel Cells, micro-turbines, biomass, and tidal sources, Concept of distributed generations, topologies, selection of sources, regulatory standards/ framework, Standards for interconnecting Distributed resources to electric power systems: IEEE 1547, DG installation classes, security issues in DG implementations. Energy storage elements: Batteries, ultra-capacitors, flywheels, Captive power plants.

Unit-II: Impact of Grid Integration
Requirements for grid interconnection, limits on operational parameters, voltage, frequency, THD response to grid abnormal operating conditions, islanding issues. Impact of grid integration with NCE sources on existing power system: reliability, stability and power quality issues.

Unit-III: Micro Grid
Concept and definition of micro-grid, micro-grid drivers and benefits, review of sources of micro-grids, typical structure and configuration of a micro-grid, AC micro-grids, Power Electronics interfaces in AC micro-grids.

Unit-IV: DC Micro Grid
DC micro-grids, Power Electronics interfaces in DC, modes of operation and control of micro grid, grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques.

Unit-V: Power quality issues, control and operation of Micro Grid

Power quality issues in micro-grids- Modeling and Stability analysis of Micro-grid, regulatory standards, Micro-grid economics, Introduction to smart micro-grids, Modes of operation and control of micro-grid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques, micro-grid communication infrastructure.

Text Books:

1. AmirnaserYezdani, and Reza Iravani, “Voltage Source Converters in Power Systems: Modeling, Control and Applications”, IEEE John Wiley Publications,2009.
2. DorinNeacsu, “Power Switching Converters: Medium and High Power”, CRC Press, Taylor & Francis, 2006.
3. Chetan Singh Solanki, “Solar Photo Voltaics”, PHI Course Pvt. Ltd.,New Delhi,2009.
4. J.F. Manwell, “Wind Energy Explained, theory design and applications,” J.G. McGowan Wiley publication, 2002.
5. D. D. Hall and R. P. Grover, “Biomass Regenerable Energy”, John Wiley, New York, 1987.
6. John Twidell and Tony Weir, “Renewable Energy Resources” Tyalor and Francis Publications, 2005.

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M. Tech I Year - II SEMESTER(SPS)
(Elective – II)

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ENERGY CONSERVATION AND MANAGEMENT
(14SPS12E2b)

Course Objectives:

- To understand the present energy scenario and the need for energy conservation, various energy Conservation measures would be learnt
- To comprehend the concepts of Energy Planning and forecasting techniques for Performing energy analysis
- To be understand the methods of pollution controls produced during energy generation
- To be familiar with various energy policies (National and International) & standards

Course Outcomes:

After Completion of this course students will be able to

- Identify basic concepts of present energy scenario and need for energy conservation
- Perform Energy Auditing
- Accomplish energy planning and forecasting
- Define energy Pollution from Energy Generation, Greenhouse effect & Global warming
- Analyze the factors affecting efficiency

UNIT I: Energy Forecasting and Econometrics Techniques
Energy Scenario - world and India. Energy Resources- Availability in India. Energy consumption pattern. Energy conservation potential - Industries and commercial establishments. Energy intensive industries - overview. Energy conservation and energy efficiency – needs and advantages, Energy demand – supply balancing, Energy models, Software for energy planning, Simulation and forecasting of future energy demand consistent with macroeconomic parameters in India, Basic concept of Econometrics (OLS) and statistical analysis (Multiple Regression), Econometrics techniques used for energy analysis and forecasting with case studies from India.

UNIT II: Pollution from Energy Generation
Coal and Nuclear based Power Plants – Fly Ash generation and environment impact, Fly ash utilization and disposal, nuclear fuel cycle, radioactive wastes – treatment and disposal- Environmental pollution limits guidelines for thermal power plant pollution control- Environmental emissions from extraction, conversion, transport and utilization of fossil fuels- Greenhouse effect- Global warming.

UNIT III: Energy Policies
National energy policy in the last plan periods, Energy use and Energy supply, Overview of renewable energy policy and the Five Year Plan programmers, Basic concept of Input-Output analysis, Concept of energy multiplier and implication of energy multiplier for analysis of regional and national energy policy- Carbon Trading- Renewable Energy Certification – CDM.

UNIT IV: Energy Conservation, Auditing and Management
Definition, need, and types of energy audit; Energy management (audit) approach: Understanding energy costs, bench marking, energy performance, matching energy use to requirement, maximizing system

efficiencies, optimizing the input energy requirements; Fuel & energy substitution, Principles of energy management, organizing energy management program, initiating, planning , controlling, promoting, monitoring, reporting.

UNIT V: Energy Efficient Motors

Energy efficient motors, factors affecting efficiency, loss distribution, constructional details, characteristics - variable speed, variable duty cycle systems, RMS hp- voltage variation-voltage unbalance- over motoring- motor energy audit.

Text Books:

1. Steve Doty, Wayne C. Turner “Energy management handbook”, 7th Edition, the Fairmont Press, Inc., 2009.
2. Michael Wickens “Macroeconomic Theory: A Dynamic General Equilibrium Approach”, Princeton University Press, 2009
3. F Kreith , D. Y Goswami, “Energy management and conservation handbook”, CRC Press, 2008
4. Y P Abbi and Shashank Jain. “Handbook on Energy Audit and Environment Management”, TERI Publications, 2006
5. R Loulou, P R Shukla and A Kanudia, “Energy and Environment Policies for a sustainable Future”, Allied Publishers Ltd, New Delhi, 1997
6. Energy management by Paul o’ Callaghan, Mc-graw Hill Book company-1st edition, 1998
7. Energy efficient electric motors by John C. Andreas, Marcel Dekker Inc Ltd-2nd edition, 1995

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M. Tech I Year - II SEMESTER(SPS)
(Elective – II)

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SOLAR POWER SYSTEM - LCOE AND FINANCIAL ANALYSIS (14SPS12E2c)

Course Objectives:

- To obtain basic knowledge of energy economics
- To become familiar with economic analysis of energy system
- To understand the renewable energy technology development priorities
- To become familiar with the concepts and methods of energy economics to solar energy systems
- To understand the energy policy and security aspects of energy

Course Outcomes:

After Completion of this course students will be able to

- Define & estimate the LCOE
- Realize about the methods for financing solar power projects and define the regulations for them
- Evaluate the financial traits for solar PV power systems through Software
- Design the plant by keeping Electrical, mechanical, electronics and civil engineering in view
- Draw the layout of the plant and to estimate the plant and substation costs

UNIT I: LCOE

Definition of LCOE, LCOE uses, Estimation of LCOE, different generating technology LCOEs, grid parity and the PV market, example of LCOE analyses.

UNIT II: Basics of Financial Analysis and Plant cost

Introduction to financial and economic performance - Merits and limitations for solar power projects - time value of money, benefits/cost ratios, discount rate, standard and discount payback period, depreciation and net present benefit, performance metrics –NPV and LCOE - Uncertainty over financial incentives-Methods for financing solar power projects-regulations, and legislation, Hardware cost (Bill of materials), solar PV panels, mounting structure, inverters, cables and wires, connectors/junction boxes, fuses, protection switches, inverters, transformers, switch yard, land and site preparation cost, permits cost, environmental clearance.

UNIT III: PV System Economics and Design & Engineering cost

Introduction, Relevance of economic and financial viability evaluation of solar power systems, Basics of engineering economics, Volume and Course effects on costs of solar power systems, Financial and other incentives for promotion of solar power systems and their effect on financial and economic viability, Financial assespects of solar PV power systems, Carbon finance potential of solar PV power and associated provisions, Software for financial evaluation of solar PV power systems, Case studies on financial and economic feasibility evaluation of solar PV power systems, Electrical design, mechanical design, electronics design, engineering and layout of the plant cost, substation cost.

UNIT IV: Plant procurement, installation, operation and maintenance cost

Purchase and procurement of power plant components, EPC cost, Installation cost, Quality control cost, logistics and management, inspection and testing, commissioning tests, and consultancy fees, Operational cost – scheduled and unscheduled Maintenance cost – Scheduled, unscheduled and repair cost.

UNIT V: LCOE estimation

Computation of energy generation cost, sensitivity of LCOE on finance, solar radiation, plant components reliability, and climatic degradation factors, parameters depends on LCOE, LCOE Vs Location, module cost Vs. Degradation rate, LCOE Vs. System availability, LCOE sensitivity, limitations of LCOE, LCOE comparison with conventional technology grid.

Text Books:

1. Kreith F., Goswami D.Y. Energy Management and Conservation Handbook, Taylor and Francis, 2008.
2. Aswathanarayana U. Green Energy: Technology, Economics and Policy, CRC Press, 2010.
3. CIPEC. Energy Savings Toolbox, Natural Resources Canada, 2007.
4. Russell, C. Managing Energy from the Top Down, Fairmount Press, 2010.
5. Mallon K. Renewable Energy Policy and Politics, Earthscan, 2006.
6. Danny Harvey L.D. Energy and the New Reality 2: Carbon-Free Energy, Earthscan, 2010.
7. LCOE by By Tarn Yates and Bradley HibberdThe New PV Metric.

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M. Tech I Year - II SEMESTER(SPS)

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SOLAR SIMULATION LAB
(14SPS12P02)

Course Objectives:

- To obtain the basic simulation concepts related to solar photovoltaic cell, batteries and fuel cells
- To become familiar with the simulation model of fault analysis, DC-DC converter and DC-AC inverter
- To understand the operating characteristics of batteries, fuel cells, solar PV modules, micro-grid systems and BIPV system
- To model the control and understand the operation of solar system

Course Outcomes:

After Completion of this course students will be able to

- Perform modeling of Solar cell performance to compute power, efficiency and fill factor, fault analysis for Solar power plant, DC-DC converter, DC-AC inverter, Lithium Ion battery, Fuel Cell and thin film monolithic integrated Solar PV modules
- Layout optimization for utility scale Solar power plant
- Identify Intelligent control system for Solar power grid system

List of Experiments:

1. Modeling of Solar cell performance to compute power, efficiency and fill factor
2. Modeling of energy loss analysis from Solar cell to module conversion
3. Layout optimization for utility scale Solar power plant
4. Intelligent control system for Solar power grid system
5. Modeling of fault analysis for Solar power plant
6. Modeling of DC-DC converter
7. Modeling of DC-AC inverter
8. Modeling of Lithium Ion battery
9. Modeling of Fuel Cell
10. Modeling of thin film monolithic integrated Solar PV modules
11. Modeling and verification of leakage currents in Solar PV modules
12. Modeling of DC micro-grid system
13. Modeling of building integrated Solar PV power system