MAHATMA GANDHI MISSION`S

JAWAHARLAL NEHRU ENGINEERING COLLEGE

AURANGABAD.

DEPARTMENT OF ELECTRICAL ENGINEERING

Curriculum for

M.Tech. in ELECTRICAL POWER SYSTEM

w.e.f.

Academic Year

2020-21

Vision Statement of Institute

To create self-reliant, continuous learner and competent technocrats imbued with human values.

Mission Statements of Institute

1. Imparting quality technical education to the students through participative teaching –learning process.
2. Developing competence amongst the students through academic learning and practical experimentation.
3. Inculcating social mindset and human values amongst the students.

Vision Statement of Department

To Develop competent Electrical Engineers with human values.

Mission Statement of Department

1. To Provide Quality Technical Education to the Students Through Effective Teaching-Learning Process.
2. To Develop Student's Competency through Academic Learning, Practical's And Skill Development Programs.
3. To Encourage Students for Social Activities and Develop Professional Attitude Along With Ethical Values.

Program Educational Objectives (PEOs)

1. To equip the engineers of tomorrow to cope up with the fast-paced field of Electrical Engineering.
2. To update the students with the latest cutting-edge technologies by organizing talks, seminars and workshops.
3. To reinforce the importance of team work in students by undertaking minor and major projects.
4. To inculcate an attitude of commitment to quality among students.

Program Specific Objectives (PSOs)

At the end of the program, the student

PSO 1: Should able to apply the knowledge gained during the course of the program from Applied Science and all electrical courses in particular to identify, formulate and solve real life electrical problems faced in industries and research work.
PSO 2: Should able to provide socially acceptable technical solutions to complex electrical engineering problems with the application of modern and appropriate techniques for sustainable development.
PSO 3: Should able to provide electrical services in power system design and development of efficient drives.

Programme Outcomes (POs)

PO No.	**Program Outcome Description**
PO 1	Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	Design / Development of solution: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO 4	Conduct investigation of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO 5	Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO 6	The engineer & society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	Environment & sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	Individual & team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	Project management & finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	Lifelong learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Semester I

Course code*	Course Title	Teaching Scheme			Evaluation Scheme						Minimum Passing						
					Internal			External			Internal			External			
(Mandatory)		L	T	P	CA	MSE	TW	ESE	PR	Total	CA	MSE	TW	ESE	PR	Total	**Credit**
20PEE101D	Advanced Power Converter	3	1	0	20	20	-	60	-	100	8	8	-	24	-	40	4
20PEE102D	Energy Storage Systems	4	0	0	20	20	-	60	-	100	8	8	-	24	-	40	4
20PEE103D	Power System Modeling	4	0	0	20	20	0	60	0	100	8	8	-	24		40	4
	Electives																
20PEE104E	1.Control &Integration of Renewable Energy Sources																
20PEE105E	2. Swarm Intelligent Techniques																
20PEE106E	3. Power System Reliability & Planning	3	0	0	20	20	0	60		100	8	8	-	24	-	40	3
	Electives																
20PEE107E	1. Instrumentation in Power System																
20PEE108E	2. Energy Management & Auditing																
20PEE109E	3. Distributed Generation & MicroGrid	3	0	0	20	20	0	60		100	8	8	-	24	-	40	3
20PEE110L	Software Technologies in Power System	0	-	4	-	-	25	-	25	50	-	-	10	-	10	20	2
20PEE111L	Power system Lab-I	0	-	4	-	-	25	-	25	50	-	-	10		10	20	2
	Total	17	1	8	100	100	50	300	50	600							22

Semester II

Course code*	Course Title	Teaching Scheme			Evaluation Scheme						Minimum Passing						Credit
					Internal			External			Internal			External			
(Mandatory)		L	T	P	CA	MSE	TW	ESE	PR	Total	CA	MSE	TW	ESE	PR	Total	Credit
20PEE201D	Advanced Power System Protection	3	1	0	20	20	-	60	-	100	8	8	-	24	-	40	4
20PEE202D	Power System Dynamics & Control	4	0	0	20	20	-	60	-	100	8	8	-	24	-	40	4
20PEE203S	Seminar – I	0	-	2	-	-	25	-	25	50	-	-	10	-	10	20	2
	Electives																
20PEE204E	1.Power Sector Economics Restructuring & Regulation																
20PEE205E	2. Power System Automation																
20PEE206E	3. Control Design Techniques For Power Electronic Systems	3	0		20	20	-	60	-	100	8	8	-	24	-	40	3
	Electives																
20PEE207E	1.Electrical & Hybrid Vehicles																
20PEE208E	2.Power Quality Assessment and Mitigation																
20PEE209E	3.ANN & its applications in Power System	3	0		20	20	-	60	-	100	8	8	-	24	-	40	3
	Electives																
20PEE210E	1.Distribution System Planning and Automation																
20PEE211E	2.Smart Grid Technologies																
20PEE212E	3.Digital Controllers In Power Electronics Applications	3	0		20	20	-	60	-	100	8	8	-	24	-	40	3
20PEE213L	Power system Lab-II	0	0	4			25		25	50			10		10	20	2
	Total	16	1	6	100	100	50	300	50	600							21

Semester III

Course code*	Course Title	Teaching Scheme			Evaluation Scheme						Minimum Passing						Credit
					Internal			External			Internal			External			
(Mandatory)		L	T	P	CA	MSE	TW	ESE	PR	Total	CA	MSE	TW	ESE	PR	Total	Credit
20PEE301M	Project Management and Intellectual Property Rights (Self Study)*	-	-	-	-	-	50	-	50	100	-	-	20	-	20	40	2
20PEE302P	Project Stage - I	-	-	-	-	-	50	-	50	100	-	-	20	-	20	40	14
	Total						100		100	200							16

Semester IV

Course code*	Course Title	Teaching Scheme			Evaluation Scheme						Minimum Passing						Credit
					Internal			External			Internal			External			
(Mandatory)		L	T	P	CA	MSE	TW	ESE	PR	Total	CA	MSE	TW	ESE	PR	Total	Credit
20PEE401P	Project Stage - II	-	-	-	-	-	100	-	100	200	-	-	40	-	40	80	28
	Total						100		100	200							28

L- Lecture, T-Tutorial, P-Practical, CA- Continuous Assessment, MSE- Mid Semester Examination, ESE- End Semester Examination, PR-Practical, TW-Term Work.

SEMESTER I

Course Code: 20PEE101D	Advanced Power Converters	Total credits: 04
Teaching Scheme		Evaluation Scheme
		Mid Sem: 20Marks
Theory: 03 Hrs/week		Simulation Assignment: 20 Marks
Tutorial: 01Hr/week		End-Semester: 60

Course Objectives	1. To understand the working of Power Electronics Converters. 2. To analyse the operation of Power Electronics Converters. 3.To apply the knowledge of Power Electronics Converters for simulation.
Course Outcomes	Students will be able to 1.Understand working of power electronics circuits. 2.Analyse working of power electronics converters. 3. Apply the knowledge to build circuit. 4. Develop application circuit simulation of power electronics. 5. Perform different analysis on circuit simulation.
Pre-requisites	**Power Electronics**
Course Type	***Program Core Course***

Course Contents

Unit No	*CO Mapping*	*PO Mapping*	*PSO Mapping*	*Competency*	*PI*	**Teaching Methodology*	*Remark*
Unit 1: Power Semiconductor Devices							
Static and dynamic characteristics of switching devices: Power Diode, SCR, BJT, MOSFET, IGBT, GTO, MCT. Design of drive and snubber circuits.	*CO1*	*PO1,2*	*PSO1, PSO2*	*1.2 1.5 2.1*	*1.2.1 1.6.1 2.5.1 2.5.2*	***Interactive teaching with the help of ICT***	
Unit 2: AC-DC converter							

Uncontrolled rectifier, semi-controlled rectifiers, fully controlled rectifiers with R, RL and RLE load, effect of source inductance on performance of converter, firing schemes and circuits, Multi-pulse converters: 12,18 and 24 pulse converters, phase shifting transformers, Power factor improvement techniques, PWM rectifiers, equal area PWM, sine PWM, Single Phase and Three phase boost rectifier circuits	***CO2***	***PO1,2,3***	***PSO1, PSO2***	***1.2 1.5 2.1 2.8 3.7***	***1.2.1 1.6.1 2.5.1 2.5.2 2.8.2 3.7.1***	***Interactive teaching with the help of ICT***	
Unit 3: Resonant Converters							
Introduction, need of resonant converters, Classification of resonant converters, load resonant converters, Resonant switch converters, zero voltage switching dc-dc converters, zero current switching dc-dc converters, clamped voltage topologies	***CO2***	***PO1,2,3***	***PSO1, PSO2***	***1.2 1.5 2.1 2.8 3.7***	***1.2.1 1.6.1 2.5.1 2.5.2 2.8.2 3.7.1***	***Interactive teaching with the help of ICT***	
Unit 4: Multilevel Converters							
Need for multi-level inverters, Concept of multi-level, Topologies for multi-level: Diode Clamped, flying capacitor and Cascaded H-bridge multilevel Converters configurations; Features and relative comparison of these configurations' applications, Introduction to carrier based PWM technique for multi-level converters.	***CO2***	***PO1,2,3***	***PSO1, PSO2***	***1.2 1.5 2.1 2.8 3.7***	***1.2.1 1.6.1 2.5.1 2.5.2 2.8.2 3.7.1***	***Interactive teaching with the help of ICT***	
Unit 5: DC Power Supply							
Fly-back Converter, Forward Converter, Push-Pull Converter, Half Bridge Converter, Full Bridge Converter, Control Circuits.	***CO2***	***PO1,2,3***	***PSO1, PSO2***	***1.2 1.5 2.1 2.8 3.7***	***1.2.1 1.6.1 2.5.1 2.5.2 2.8.2 3.7.1***	***Interactive teaching with the help of ICT***	
Unit 6: Circuit Simulation							
Characteristics of Power Electronics Devices, AC-DC Converters, Resonant Converters, Multilevel Inverters, DC Power Supply	***CO3***	***PO1,2,3, 4,5***	***PSO1, PSO2, PSO3***	***1.2 1.5 2.1 2.8 3.7 4.4 5.5***	***1.2.1 1.6.1 2.5.1 2.5.2 2.8.2 3.7.1 4.4.1 5.5.1***	***Interactive teaching with the help of MATLAB***	

Textbooks:

1. Power Electronics: Circuits, Devices and Applications by Muhammad Rashid, Third Edition, Pearson Education, Inc.
2. Power electronics M. D. Singh, K.B. Khanchandani, second Edition Tata McGraw Hills.

Reference Books:

1 Static relays, T.S.Madhava Rao, TMH publication, second edition 1989.

2. Protection and Switchgear, Bhavesh Bhalja, R. P. Mahesheari, Nilesh G. Chothani, Oxford University Press.

3. Electrical Power System Protection, C. Christopoulos and A. Wright, Springer International.

E-sources:

1. ***https://nptel.ac.in ›Advance power electronics courses***

Course Code: *20PEE102D*	***Energy Storage Systems***	***Total credits: 04***
Teaching Scheme		***Evaluation Scheme***
Theory : 4 Hrs/week		***CA: 20 Marks***
Tutorial: ---Hr/week		***Mid Sem: 20 Marks***
		End Sem: 60 Marks

Course Objectives	Student will be able to 1. Learn different principles of energy storage and conversion. 2.Know about feasibility of different energy storage devices and their integration in power system 3. Learn new energy storage systems namely battery and Ultra-capacitor. 4. Explore different converter topologies for Energy storage system
Course Outcomes	Students will be 1. Explain the fundamental principles of energy storage 2. Analyze, model an Energy system to know its performance. 3. Know battery storage system based on load requirement. 4. Design a converter topology for hybrid energy storage system 5. Know energy storage device based on load delivery pattern.
Pre-requisites	Power system analysis
Course Type	***Program Core Course***
Course Contents	

Unit No.	***PO Mapping***	***PSO Mapping***	***Teaching Methodology***	***CO Mapping***	***Competency***	***PI***
Unit 1: Conventional energy storage systems						
Compressed gas storage system: bulk energy storage. System cost, capacity, conversion efficiency, Flywheel: Models for flywheel capacity, availability, efficiency, and self-discharge, Applications in transportation, uninterruptible power supply (UPS).	PO1, PO2, PO3,	PSO1	Explanation by Qualitative Discussion *PPT	CO 1 CO 2	1.2 2.1 3.1	1.2.1 2.1.1 3.1.1
Unit2: Battery energy storage system						
Battery specifications and performance characteristics, emerging battery technologies. Comprehensive analysis of design considerations and application specific needs. Impacts on system cost in terms of life cycle, environmental, and reliability of the end solutions. Batteries for Automobiles and Electric Vehicles: Specifications and performance characteristics of Lead-Acid, Nickel-Cadmium, Nickel-Metal, Hydride and, Lithium-Ion Batteries.	PO1, PO2, PO3 PO7	PSO1	Explanation by Qualitative Discussion *Problem Based	CO 2 CO 3	1.2 2.1 3.1 7.1	1.2.1 2.1.3 3.1.5 7.1.1
Unit3: Capacitors						

Introduction to ultra-capacitors including operation, applications, and emerging technologies. Topics include the usage in mobile applications and close proximity to renewable energy sources. Discussion of primary target market usage in today's energy and power sectors.	***PO1, PO2, PO3***	***PSO1***	***Explanation by Qualitative Discussion *Problem Based***	***CO 2 CO 3***	***1.2 2.1 3.1***	***1.2.1 2.1.1 3.1.1***
UNIT4: Hybrid energy storage systems						
Battery-Ultra capacitor hybrid storage systems: Matching characteristics both energy devices supplying a common load. Energy and power management of Hybrid energy storage system, control strategies for applications like Electric vehicle and grid connected renewable.	***PO1, PO2, PO3***	***PSO1***	***Explanation by Qualitative Discussion***	***CO 4 CO 5***	***1.2 2.1 3.1***	***1.2.1 2.1.1 3.1.1***
UNIT 5: Fuel Cells						
Introduction to fuel cells. Topics include understanding of operation, benefits, economics, lifetimes and failure mechanisms. Application of fuel cells in the bulk power and energy system.	***PO1, PO2, PO3***	***PSO1***	***Explanation by Qualitative Discussion***	***CO 2 CO 5***	***1.2 2.1 3.1***	***1.2.1 2.1.1 3.1.1***
UNIT 6: Converter topology for Electric energy storage and utility						
Design of converters for battery storage, standalone PV system and grid integration with renewables.	***PO1, PO2, PO3***	***PSO1***	***Explanation by Qualitative Discussion***	***CO 5***	***1.2 2.1 3.1***	***1.2.1 2.1.1 3.1.1***

TEXT BOOKS:

1. Sukhatme,S.P., "Solar Energy", TataMcGrawHill,1984
2. Kishore V V "Renewable Energy Engineering and Technology" ,Teri Press,NewDelhi,2012

REFERENCE BOOKS:

1. Thaler, Alexander, Watzenig, Daniel, "Automotive Battery Technology" Springer
2. A.TerGazarian, "Energy storage for Power Systems", Peter Peregrinus Ltd on behalf of Institution of Electrical Engineers
3. Ibrahim Dincer and Mark A. Rosen, Thermal Energy Storage Systems and Applications, John Wiley & Sons 2002
4. Fuel cell systems Explained, James Larminie and Andrew Dicks, Wiley publications, 2003.
5. Electrochemical technologies for energy storage and conversion, Ru-shiliu, Leizhang, Xueliang sun, Wiley publications, 2012
6. Robert Huggins, "Energy storage –Fundamentals,Materials And Applications ",Springer

E-sources: Online course on "Energy Storage Systems"

Course Code : 20PEE103D	Power System Modeling	Total credits: 04
Teaching Scheme		Evaluation Scheme
		CA : 20 Marks
Theory : 04 Hrs/week		Mid sem: 20Marks
Tutorial: -Hr/week		End-Semester : 60 Marks

Course Objectives	1.To describe characteristics of power system components such as synchronous machine, transmission line, transformer, induction motor, excitation systems. 2.To develop appropriate mathematical models of power system components such as synchronous machine, transmission line, transformer, induction motor, excitation systems. 3. To study the steady state and transient performance characteristic of synchronous machine.
Course Outcomes	Students will be able to 1.Develop power system components modelling and analyse their performance 2. Develop modelling of synchronous machine and analyse its performance. 3.Perform steady state and dynamic analysis on simulation models 4. Understand configuration and functioning of synchronous machine excitation system. 5. Develop excitation system components modelling and analyse their performance. 6. Understand and transmission line, load and reactive power compensator modelling.
Pre-requisites	***Power system Analysis, Power Electronics***
Course Type	***Program Core Course***

Course Contents

Unit No.	***CO Mapping***	***PO Mapping***	***PSO Mapping***	***Competency***	***PI***	***Teaching Methodology***	***Remark***
Unit 1: Modelling of Power System Components							
The need for modelling of power system, different areas of power system analysis. Models of non-electrical components like boiler, steam & hydro-turbine & governor system. Transformer modelling such as auto-transformer, tap-changing & phase shifting transformer	CO1, CO2	***PO1 PO2 PO3 PO4 PO5***	***PSO1 PSO3***	***1.3, 2.1,2.4, 3.1, 4.1, 5.1***	***1.3.1 2.1.2 2.1.3 2.4.1 3.1.6 4.1.1 5.1.1***	***Interactive teaching with the help of ICT***	
Unit 2: Synchronous machine modelling							

Model required for steady-state analysis. The development of model required for dynamic studies. The current & flux linkage models using Park's transformation leading to simulation as linear model.	***CO2, CO3***	***PO1 PO2 PO3 PO4 PO5***	***PSO1 PSO3***	***1.3, 2.1,2.4, 3.1, 4.1, 5.1***	***1.3.1 2.1.2 2.1.3 2.4.1 3.1.6 4.1.1 5.1.1***	***Interactive teaching with the help of ICT***	
Unit 3: Analysis of synchronous machine modelling							
Synchronous machine connected to an infinite bus, its simulation for steady-state condition	***CO3***	***PO1 PO2 PO3 PO4 PO5***	***PSO1 PSO3***	***1.3, 2.1,2.4, 3.1, 4.1, 5.1***	***1.3.1 2.1.2 2.1.3 2.4.1 3.1.6 4.1.1 5.1.1***	***Interactive teaching with the help of ICT***	
Unit 4: Excitation systems							
Simplified view of excitation control. Excitation configuration, primitive systems, Definitions of voltage response ratio & exciter voltage ratings.	***CO4, CO5***	***PO1 PO2 PO3 PO4 PO5***	***PSO1 PSO3***	***1.3, 2.1,2.4, 3.1, 4.1, 5.1***	***1.3.1 2.1.2 2.1.3 2.4.1 3.1.6 4.1.1 5.1.1***	***Interactive teaching with the help of ICT***	
Unit 5: Excitation system modelling							
Excitation control systems using dc generator exciter, alternator-rectifier, alternator SCR, and voltage regulators such as electro-	***CO5***	***PO1 PO2 PO3 PO4 PO5***	***PSO1 PSO3***	***1.3, 2.1,2.4, 3.1, 4.1, 5.1***	***1.3.1 2.1.2 2.1.3 2.4.1 3.1.6 4.1.1 5.1.1***	***Interactive teaching with the help of ICT***	

mechanical and solid state. Modelling of excitation systems							
Unit 6: Transmission line, SVC and load modelling							
Transmission line modelling, Modelling of static V AR compensators, load modelling	***CO6***	***PO1 PO2 PO3 PO4 PO5***	***PSO1 PSO3***	***1.3, 2.1,2.4, 3.1, 4.1, 5.1***	***1.3.1 2.1.2 2.1.3 2.4.1 3.1.6 4.1.1 5.1.1***	***Interactive teaching with the help of ICT***	

Text Books :

1. P. Kundur, "Power System Stability and Control", McGraw-Hill, 1993.
2. R.Ramunujam," Power System Dynamics Analysis and Simulation, PHI Learning

Reference Books :

1. Electric Power Systems: B.M. Weddy and B.J. Cory, John Wiely and Sons, Fourth edition (2002).
2. Power System Analysis and Design :J. Duncan Glover, MulukutlaS. Sarma, Thomson Brooks/cole/ Third Edition (2003)

E-Resources :

1. https://nptel.ac.in › courses

Course Code : 20PEE104E	Control & Integration of Renewable Energy Sources	Total credits: 03
Teaching Scheme		Evaluation Scheme
		CA: 1 and CA:2 *(Min.10 marks each):20*
Theory : 03 Hrs/week		Mid sem: 20Marks
Tutorial: -Hr/week		End-Semester : 60 Marks

Course Objectives	1. To learn the principles of generating Heat Energy and Electrical energy from Non-conventional / Renewable Energy Sources. 2. To gain understanding of the working of Off-grid and Grid-connected Renewable Energy Generation Schemes.
Course Outcomes	*Students will be able to* 1. Knowledge on different renewable energy sources and storage devices. 2. Recognize, model and simulate different renewable energy sources. 3. Analyze, model and simulate basic control strategies required for grid connection. 4. Implement a complete system for standalone/grid connected system.
Pre-requisites	
Course Type	Professional Elective course.

Course Contents

Unit No.	***CO Mapping***	***PO Mapping***	***PSO Mapping***	***Competency***	***PI***	***Teaching Methodology***	***Remark***
Unit 1 : Introduction							
Distributed vs. Central Station Generation, Sources of Energy such as Micro-turbines ,Electric grid introduction, Supply guarantee and power quality, Stability, Effects of renewable energy penetration into the grid, Boundaries of the actual grid configuration, Consumption models and patterns, static and dynamic energy conversion technologies, interfacing requirements.	***CO1,CO2,CO3***	***PO1,PO2 PO3***	*PSO2,PSO3*	***1.1 1.3 2.3 3.3***	***1.1.2 1.3.1 2.3.2 3.1.1***	*ICT AND Classroom discussion.*	
Unit 2: Dynamic Energy Conversion Technologies.							
Introduction to different conventional and nonconventional dynamic generation technologies, principle of operation and analysis of reciprocating engines, gas and micro turbines, hydro and wind based generation	***CO2,CO3***	***PO1,PO2***	***PSO1,PSO 2***	***1.3 2.2***	***1.3.1 2.2.2***	***ICT AND Classroom discussion.***	

technologies, control and integrated operation of different dynamic energy conversion devices. Plant Design: Technology selection, layouts, electrical design, array design, sizing of inverters, cables, fuses and protection devices, optimizing system design and its construction Commissioning of plant: General recommendation, pre-connection acceptance testing, grid connection, post connection acceptance testing, provisional acceptance.							
Unit 3 : Static Energy Conversion Technologies							
Introduction to different conventional and nonconventional static generation technologies, principle of operation and analysis of fuel cell, photovoltaic based generators, and wind based generation technologies, different storage technologies such as batteries, fly wheels and ultra capacitors, plug-in-hybrid vehicles, control and integrated operation of different static energy conversion devices**.**	***CO2,CO3, CO4***	***PO2,PO3 PO4,PO5***	***PSO1,PSO 2***	***2.2 3.2 4.2***	***2.2.4 3.2.3 4.2.1***	***ICT AND Classroom discussion.***	
Unit 4: Real and reactive power control							
Control issues and challenges in Diesel, PV, wind and fuel cell based generators, PLL, Modulation Techniques, Dimensioning of filters, Linear and nonlinear controllers, predictive controllers and adaptive controllers, Fault-ride through Capabilities, Load frequency and Voltage Control. Grid connected and stand-alone Wind Power Generation using Squirrel cage induction machines,	***CO3, CO4***	***PO4,PO5 PO6***	***PSO2,PSO 3***	***4.2 5.1 6.1***	***4.2.1 5.1.1 6.1.1***	***ICT AND Classroom discussion.***	

Grid connected and stand-alone Wind Power Generation using Doubly fed induction machines, Grid connected and stand-alone Wind Power Generation using Permanent magnet synchronous machines.							
Unit 5: Integration of different Energy Conversion Technologies.							
Resources evaluation and needs, Dimensioning integration systems, Optimized integrated systems, Interfacing requirements, integrated Control of different resources, Distributed versus Centralized Control, Synchro Converters, Grid connected and Islanding Operations, stability and protection issues, load sharing, Cases studies.	***CO4, CO5***	***PO3, PO5 PO6***	***PSO2, PSO3***	***3.3 5.2 6.1***	***3.3.1 5.2.1 6.1.1***	***ICT AND Classroom discussion.***	

Text Books :

1. Ali Keyhani Mohammad Marwali and Min Dai, "Integration and Control of Renewable Energy in Electric Power System" John Wiley publishing company
2. S. Chowdhury, S. P. Chowdhury, P. Crossley, "Microgrids and Active Distribution Networks", IET Power Electronics Series, 2012
3. G. Masters, "Renewable and Efficient Electric Power Systems", IEEE-Wiley Publishers, 2013.
4. Ranjan Rakesh, Kothari D.P, Singal K.C, „Renewable Energy Sources and Emerging Technologies‟, 2ndEd. Prentice Hall of India, 2011

Reference Books :

1. Quing-Chang Zhong, "Control of Power Inverters in Renewable Energy and Smart Grid Integration", Wiley, IEEE Press
2. Bin Wu, Yongqiang Lang, NavidZargari, "Power Conversion and Control of Wind Energy Systems", and Wiley 2011.
3. Math H. Bollen, Fainan Hassan, "Integration of Distributed Generation in the Power System", July 2011, Wiley –IEEE Press.

Course Code : 20PEE105E	**SWARM INTELLIGENT TECHNIQUES**	*Total credits: 03*
Teaching Scheme		*Evaluation Scheme*
		CA : 20 Marks
Theory : 03 Hrs/week		*Mid sem: 20Marks*
Tutorial: -Hr/week		*End-Semester : 60 Marks*

Course Objectives	Student will be able to 1. Learn conventional & bio-inspired systems 2.Know importance of exploration and exploitation swarm intelligent system 3. Learn functioning of various swarm intelligent systems 4. Explore various bio-inspired algorithms for Power systems problems.
Course Outcomes	Students will be able to 1. Discriminate the capabilities of bio-inspired system 2. Know conventional methods in solving optimization. 3. Examine the importance of exploration and exploitation swarm intelligent system 4. Distinguish the functioning of various swarm intelligent systems. 5. Employ various bio-inspired algorithms for Power systems problems.
Pre-requisites	Optimal System in Control System.
Course Type	Elective Course

Course Contents

Unit No.	***CO Mapping***	***PO Mapping***	***PSO Mapping***	***Competency***	***PI***	***Teaching Methodology***	***Remark***
Unit 1: Fundamentals of soft computing techniques							
Definition-Classification of optimization problems- Unconstrained and Constrained optimization Optimality conditions- Introduction to intelligent systems- Soft computing techniques- Properties of Swarm intelligent Systems - Application domain - Discrete and continuous problems - Single objective and multi-objective problems.	***CO1***	***PO1, PO2,PO3, PO4***	***PSO1***	***1.6 2.1 3.5***	***1.6.1 2.5.1 3.6.1***	***ICT TOOLS***	
Unit 2:Genetic algorithm and particle swarm optimization							
Genetic algorithms-Genetic Algorithm versus Conventional Optimization Techniques - Genetic representations and selection mechanisms; Genetic	***CO1, 2***	***PO1, PO2,PO3, PO4***	***PSO1***	***1.6 2.1 3.5***	***1.6.1 2.5.1 3.6.1***	***ICT TOOLS***	

operators- different types of crossover and mutation operators -Bird flocking and Fish Schooling – anatomy of a particle- equations based on velocity and positions -PSO topologies - control parameters – GA and PSO algorithms for solving ELD problem.							
Unit 3: Ant colony optimization and Artificial bee colony algorithms							
Biological ant colony system - Artificial ants and assumptions - Stigmergic communications - Pheromone updating- local-global - Pheromone evaporation - ant colony system- ACO models-Touring ant colony system-max min ant system - Concept of elistic ants-Task partitioning in honey bees - Balancing foragers and receivers - Artificial bee colony (ABC) algorithms-binary ABC algorithms – ACO and ABC algorithms for solving Economic Dispatch of thermal units.	***CO1, 3***	***PO1, PO2,PO3, PO4***	***PSO1***	***1.6 2.1 3.5***	***1.6.1 2.5.1 3.6.1***	***ICT TOOLS***	
Unit 4: Shuffled frog-leaping algorithm and bat optimization algorithm							
Bat Algorithm- Echolocation of bats- Behavior of micro bats- Acoustics of Echolocation- Movement of Virtual Bats- Loudness and Pulse Emission- Shuffled frog algorithm-virtual population of frogs-	***CO1, 4***	***PO1, PO2,PO3, PO4***	***PSO1***	***1.6 2.1 3.5 4.5***	***1.6.1 2.5.1 3.6.1 4.5.1***	***ICT TOOLS***	

comparison of memes and genes - memeplex formation-memeplex updation-BA and SFLA algorithms for solving ELD and optimal placement and sizing of the DG problem							
Unit 5: Multi objective optimization							
Multi-Objective optimization Introduction-Concept of Pareto optimality - Non-dominant sorting technique-Pareto fronts-best compromise solution-min-max method-NSGA-II algorithm and applications to power systems	***CO1, 5***	***PO1, PO2,PO3, PO4***	***PSO1***	***1.6 2.1 3.5 4.5***	***1.6.1 2.5.1 3.6.1 4.5.1***	***ICT TOOLS***	

Text Books:

1. Xin-She Yang, „Recent Advances in Swarm Intelligence and Evolutionary Computation‟, Springer International Publishing, Switzerland, 2015.
2. Kalyanmoy Deb „Multi-Objective Optimization using Evolutionary Algorithms‟, John Wiley & Sons, 2001.
3. James Kennedy and Russell E Eberheart, „Swarm Intelligence‟, The Morgan Kaufmann Series in Evolutionary Computation, 2001.

Reference Books:

1. Eric Bonabeau, Marco Dorigo and Guy Theraulaz, „Swarm Intelligence-From natural to Artificial Systems‟, Oxford University Press, 1999.
2. David Goldberg, „Genetic Algorithms in Search, Optimization and Machine Learning‟, Pearson Education, 2007.
3. Konstantinos E. Parsopoulos and Michael N. Vrahatis, „Particle Swarm Optimization and Intelligence: Advances and Applications‟, Information science reference, IGI Global, , 2010.
4. N P Padhy, „Artificial Intelligence and Intelligent Systems‟, Oxford University Press, 2005.

E-sources:

Online course on "Swarm Techniques"

<table>
<tr><td>Course Code: 20PEE106E</td><td colspan="5">Power System Reliability and Planning</td><td colspan="3">Total credits: 03</td></tr>
<tr><td>Teaching Scheme</td><td colspan="5"></td><td colspan="3">*Evaluation Scheme</td></tr>
<tr><td>Theory : 3Hrs/week</td><td colspan="5"></td><td colspan="3">CA : 20 Marks</td></tr>
<tr><td>Tutorial: 0Hr/week</td><td colspan="5"></td><td colspan="3">Mid Sem: 20 Marks</td></tr>
<tr><td></td><td colspan="5"></td><td colspan="3">End Sem: 60 Marks</td></tr>
<tr><td>Course Objectives</td><td colspan="8">1-To understand the importance of maintaining reliability of power system and appreciate its role in our Society
2-To acquire and analyze the knowledge of methods for evaluating the reliability of generation, transmission and distribution systems.
3- To interpret the different models of system components in reliability and planning studies</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">Students will be able to -
1-Understand the importance of maintaining reliability of power system components
2-Apply the probabilistic methods for evaluating the reliability of generation, transmission and distribution systems.
3-Assess the different models of system components in reliability studies
4-Assess the reliability of single area and multi area systems</td></tr>
<tr><td>Pre-requisites</td><td colspan="8">Basics of Power System</td></tr>
<tr><td>Course Type</td><td colspan="8">Program Core Course</td></tr>
<tr><td>Course Contents</td><td colspan="8"></td></tr>
<tr><td>Unit No.</td><td>CO Mapping</td><td>PO Mapping</td><td>PSO Mapping</td><td>Competency</td><td>PI</td><td colspan="2">*Teaching Methodology</td><td>Remark</td></tr>
<tr><td>Unit 1: Basic Reliability Concepts
General reliability function, Exponential distribution, Mean time to failures, series and parallel systems, Markov process, continuous Markov process, Recursive techniques, Simple series and parallel system models</td><td>CO1</td><td>PO1
PO2</td><td>PSO1</td><td>1.1
2.2</td><td>1.1.1
1.1.2
2.2.3</td><td colspan="2">Classroo m Teaching</td><td></td></tr>
</table>

Unit 2: Generating Capacity and Basic Probability Methods Generation system model, Loss of load indices, Capacity expansion analysis, scheduled outages, Load forecast uncertainty Loss of energy indices, frequency and duration method.	***CO1***	***PO1 PO3***	***PSO1 PSO2***	***1.1 3.1***	***1.1.2 3.1.6***	***Smart Room Teaching, Brain Storming***	
Unit 3: Transmission Systems Reliability Evaluation Radial configuration, Conditional probability approach, Network configurations, State selection	***CO2***	***PO1 PO3***	***PSO1***	***1.1 3.1***	***1.1.1 3.1.1 3.1.2***	***Smart Room Teaching, Group Assignment and Discussion***	
Unit 4: Generation Planning Comparative economic assessment of individual generation projects, Investigation and simulation models, Heuristic and linear programming models, Probabilistic generator and load models	***CO2 CO3***	***PO1 PO3***	***PSO1 PSO3***	***1.1 3.2***	***1.1.1 3.2.2***	***Smart Room Teaching, Brain Storming***	
Unit 5: Transmission Planning Deterministic contingency analysis, Probabilistic transmission system, reliability analysis, Reliability calculations for single area and multi–area power systems	***CO2 CO3***	***PO1 PO5***	***PSO1 PSO2***	***1.3 5.2***	***1.3.1 5.2.1***	***Peer to Peer, Team Exercise***	
Unit 6: Distribution Planning Network configuration design, consisting of	***CO2 CO3***	***PO 2 PO 3 PO***	***PSO2***	***2.4 3.3 4.3***	***2.4.3 3.3.1 4.3.2***	***Emphasis of Practical Learning***	

		4					
schemes, security criteria configuration synthesis							

Text Books:

1. “Reliability Evaluation of Power Systems”, Roy Billinton and Ronald Allan Pitam, 1996
2. “Power System Planning”, R.L. Sullivan, McGraw Hill International, 1977.

Reference Books:

1. “Computational Methods in Power system Reliability”, D. Elmakias, Springer-Verlag.
2. “Forecasting methods and Applications”, Wheel Wright and Makridakis, John Wiley, 1992.
3. “Reliability Modelling in Electric Power Systems”, J. Endremyl, John Wiley, 2005.

E-sources:

1. https://onlinecourses.nptel.ac.in/explorer

Course Code: 20PEE107E	Instrumentation in power system	Total credits: 03
Teaching Scheme		*Evaluation Scheme
Practical : 03 Hrs/week		CA: 30 Marks
Tutorial- Demonstration:-		Mid Sem: 30 Marks
		End Sem: 40 Marks
Course Objectives	1- To understand the concepts of Power System Instrumentation. 2- To discuss design an selection of Power System Instrumentation sub-systems 3-To help realize design consideration ‘	
Course Outcomes	Students would be able to 1- Identify energy storage methods. 2- analyze transmission lines and instrumentation scheme used for HVDC 3- design automatic generation and voltage control in power generation station. 4.choose instrumentation schemes for monitoring and control 5. Apply signal transmission techniques for sharing process information	
Pre-requisites	*Power system, Signal and System, Basic Instrumentation*	

Course Type			
Course Contents			

	CO Mapping	PO Mapping	PSO Mapping	Competancy	PI	*Teaching Methodology	Remark
Unit.01 Power systems Structures. Conventional and unconventional sources of electric energy, Representation of power system components, Per unit (PU) system..	Co1			1.1 2.1	1.1.1 2.1.3		

UNIT-2 Mathematical modeling of Energy storage methods, Secondary batteries, Fuel cells, Hydrogen energy system, Energy management systems, instrumentation schemes adopted for energy conservation.	Co1	PO1	PSO1	***1.1 2.1***	***1.1.1 2.1.3***	***PPT And Brainstorming***	
UNIT-3 Performance analysis and simulation of Transmission lines: Inductance and resistance of transmission lines, Capacitance of transmission lines, Characteristics and performance of power transmission lines, Instrumentation scheme used for HVDC and HVAC transmission systems	***Co2***	***PO2***	***PSO1***	***1.1 2.1***	***1.1.1 2.1.3***	***Animations & physical model***	
UNIT4: Design of Automatic Generation and Voltage Control Load frequency control, Automatic voltage control, Digital LF controllers, Decentralized control, Loadflow studies,	***Co3***	***PO2 PO4***	***PSO1***	***1.1 2.1 3.1***	***1.1.1 2.1.3 3.1.2***	***Brainstorming***	
Unit-5	***Co4***	***PO2 PO4***	***PSO1***	***1.1 2.1***	***1.1.1 2.1.3***	****Problem based***	

Instrumentation schemes for monitoring and control: Instrumentation schemes for monitoring and control of various parameters of power plants through control panels, Computer based data acquisition system for power plant operation, Maintenance and protection, Use of SCADA in power systems.			***PSO2***	***3.1***	***3.1.2***		
Unit-6 Design consideration for various power generation system with respect to instrumentation viz. Hydroelectric Power Plant Instrumentation, Thermal Power Plant Instrumentation	***C05***	***PO2*** ***PO4***	***PSO1*** ***PSO2***	***1.1*** ***2.1*** ***3.1*** ***4.2***	***1.1.1*** ***2.1.3*** ***3.1.2*** ***4.1.2***	****Proble m based***	

Text Books:

1. Chakrabarti, A., Soni, M.L., Gupta, P.V. and Bhatnagar, U.S., A Text Book on Power System Engineering, Dhanpat Rai and Co. (P) Ltd. (2008).
2. Nath, R., and Chandra,M., Power System Protection and Switchgear, New Age International (P) Limited, Publishers (2003).

Reference books:

1-. Liptak, B.G., Instrument Engineers Handbook, Butterworth, Heinemann (2002) 3rd ed

E-Resources: NPTEL course on “Product System Design” & Control System

Course Code : 20PEE108E	*Energy Management & Auditing*	*Total credits: 03*
Teaching Scheme		*Evaluation Scheme*
		CA : 20 Marks
Theory : 03 Hrs/week		*MSE: 20 Marks*
		End-Semester Exam: 60

Course Objectives	1. Students should understand energy efficiency and conservation 2. Students should know energy act of govt. and methods of audit. 3. Students should know the Financial Aspects and its calculation of project.
Course Outcomes	The Students will be able to 1. To understand the concept of energy management and energy management opportunities 2. To understand the different methods used to control peak demand 3. To know energy auditing procedure 4. To understand the different methods used for the economic analysis of energy projects. 5. To Perform Energy audit and provide measures to improve efficiency
Pre-requisites	***Nil***
Course Type	***Program Core Course***
Course Contents	

Unit No.	***CO Mapping***	***PO Mapping***	***PSO Mapping***	***Competency***	***PI***	***Teaching Methodology***	***Remark***
Unit 1: Introduction to Energy Management							
Definition and Objective of Energy Management, General Principles of Energy Management, Energy Management Skills, Energy Management Strategy. Energy Audit: Need, Types, Methodology and Approach. Energy Management Approach, Understanding Energy Costs, Bench marking, Energy performance, Matching energy usage to requirements, Maximizing system efficiency, Optimizing the input energy requirements, Fuel and Energy substitution. EMS 50001, Energy Act 2001 & 2019	***CO1 CO2***	***PO1 PO2***	***PSO1***	***1.2 1.5 2.5***	***1.2.1 1.5.1 2.5.1 2.5.3***	***Interactive teaching with the help of ICT***	
Unit -02: Procedures and Techniques							
Data gathering : Level of responsibilities, energy sources, control of energy and uses of energy get Facts, figures and impression about energy /fuel and system operations, Past and	***CO3 CO5***	***PO1 PO2 PO5***	***PSO1***	***1.2 1.5 2.5 5.5***	***1.2.1 1.5.1 2.5.1 2.5.3 5.5.2***	***Interactive teaching with the help of ICT***	

Present operating data, Special tests, Questionnaire for data gathering. **Analytical Techniques:** Incremental cost concept, mass and energy balancing techniques, inventory of Energy inputs and rejections, Heat transfer calculations, Evaluation of Electric load characteristics, process and energy system simulation. **Evaluation of saving opportunities:** Determining the savings in Rs, Noneconomic factors, Conservation opportunities, estimating cost of implementation. **Energy Audit Reporting:** The plant energy study report- Importance, contents, effective organization, report writing and presentation.							
Unit 3 : Energy Manager & EMS							
Location of Energy Manager, Top Management Support, Managerial functions, Role and responsibilities of Energy Manager, Accountability. Motivating – Motivation of employees, Requirements for Energy Action Planning. Information Systems: Designing, Barriers, Strategies, Marketing and Communicating Training and Planning.	***CO2 CO4 CO5***	***PO1 PO2 PO3 PO4 PO5***	***PSO1 PSO2 PSO3***	***1.2 1.5 2.5 3.5 4.5 5.5***	***1.2.1 1.5.1 2.5.1 3.5.1 4.5.1 5.5.2***	***Project Based or Activity Teaching***	
Unit 4: Energy Audit							
Instruments for Audit and Monitoring Energy and Energy Savings, Types and Accuracy Energy Audit: Need, Types, Methodologies and steps involved in Energy Audit	***CO2 CO4***	***PO1 PO2 PO3 PO5***	***PSO1 PSO2 PSO3***	***1.2 1.5 2.5 3.5 5.5***	***1.2.1 1.5.1 2.5.1 2.5.3 3.5.1 5.5.2***	***Project Based or Activity Teaching***	
Unit 5: Economic Analysis and Financial Management							
Objectives, Investment needs, appraisal and criteria, sources of funds. Anatomy of investment – Initial investment, Return on Investment, Economic life, Basic income equations. Tax considerations: Depreciation, types and methods of depreciation, Income tax Considerations. Financial	***CO3 CO5***	***PO1 PO3 PO4***	***PSO1 PSO2 PSO3***	***1.2 1.5 2.5 3.5***	***1.2.1 1.5.1 2.5.1 2.5.3 3.5.1***	***Project Based or Activity Teaching***	

analysis: Simple pay back period, Return on investment (ROI), Net Present value (NPV), Internal Rate of Return (IRR), and Annualized cost, Time value of money, Cash flows, Discounting, Inflation Risk and sensitivity analysis, financing options. Pros and cons of the common methods of analysis							
Unit 6: Project Management							
Definition and scope of project, technical design, financing, contracting, implementation and performance monitoring. Implementation plan for top management, Planning budget, Procurement procedures, construction, Measurements and verification. Case Study.	***CO5 CO4***	***PO1 PO3 PO4***	***PSO1 PSO2 PSO3***	***1.2 1.5 2.5 3.5***	***1.2.1 1.5.1 2.5.1 2.5.3 3.5.1***	***Project Based or Activity Teaching***	

Text Books :

1. Energy Management: W.R.Murphy, G.Mckay, Butterworths Publications.
2. Energy Management Principles: C.B.Smith, Pergamon Press Publications.
3. ***Energy Management Handbook – W.C. Turner , John Wiley and Sons, A Wiley Interscience Publication.***
4. ***Energy Economics -A.V.Desai, Wieley Eastern publications.***

Reference Books :

1. ***Industrial Energy Conservation : D.A. Reay, Pergammon Press Publication***
2. ***Energy Conservation guide book Patrick/Patrick/Fardo , Prentice Hall Publications***

E-Resources :

2. https://beeindia.gov.in/content/energy-auditors ***(Guide Books for Energy Auditor)***

Course Code: 20PEE109E		**Total credits: 03**
Teaching Scheme	**Distributed Generation and Micro Grid**	**Evaluation Scheme**
Theory : 03 Hrs/week		**CA: 20 Marks**
Tutorial : 00 Hrs/week		**Mid Sem: 20 Marks**
Practical : 00 Hrs/week		**End Sem: 60 Marks**

Course Objective	1. To illustrate the concept of distributed generation 2. To analyse the impact of grid integration. 3. To study concept of Micro grid and its configuration 4. To find optimal size, placement and control aspects of DGs
Course Outcomes	Student will be able to 1. Find the size and optimal placement DG 2. Analyse the impact of grid integration and control aspects of DGs 3. Model and analyse a micro grid taking into consideration the planning and operational issues of the DGs to be connected in the system 4. Describe the technical impacts of DGs in power system to understand the need of automation and control of distribution system.
Pre-requisites	Electrical Power Generation, Electrical Power Transmission and Distribution, Power System Analysis
Course Type	Program Core Course

Course Contents

Unit No.	Co Mapping	PO Mapping	PSO Mapping	Competency	PI	Teaching Methodology	Remark
Unit 1 : Distributed generation(DG) and its need *(07Hrs)*							
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, Renewable sources in distributed generation – Current scenario in distributed generation – Planning of DGs – Siting and sizing of DGs – Optimal placement of DG sources in distribution systems.	CO 1	***PO1***	***PSO 1***	1.2	1.2.1	Interactive classroom teaching (ICT) classroom teaching	
Unit 2 : Impact Of Grid Integration and interconnection *(07Hrs)*							
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, standards for interconnecting DGs to electric power systems: IEEE 1547. DG installation classes, security issues in DG implementations. Grid code and Islanding & non-islanding system	CO 2	***PO1, PO2, PO3***	***PSO 1,PSO3***	1.1 1.2 1.3 2.1 3.1	1.1.2 1.2.1 1.3.1 2.1.3 3.1.1	ICT, classroom teaching	
Unit 3: Operation , control and modelling of micro grid *(07Hrs)*							
Concept and definition of micro-grid, review of sources of micro-grids, typical structure and configuration of a micro-grid, micro-grid implementation in Indian and international scenario, AC and DC micro-grids, Power Electronics interfaces in DC and AC micro-grids, communication infrastructure, modes of operation and control of micro-grid:	CO 3	***P03***	***PSO 1,PSO3***	3.1	3.1.1	ICT, classroom teaching	

grid connected and islanded mode operation, anti-islanding schemes. Control techniques for voltage, frequency, active and reactive power control of micro-grid system, Computer aided Modelling of micro-grid							
Unit 4: Power Quality Issues In Micro-grids *(06Hrs)*							
Power quality issues in micro-grids- Modelling and Stability analysis of Micro-grid, regulatory standards, Micro-grid economics, Introduction to smart micro-grids	CO 3	***PO1, PO2, PO3***	***PSO 1,PSO3***	1.1 1.2 1.3 2.1 3.1	1.1.2 1.2.1 1.3.1 2.1.3 3.1.1	ICT, classroom teaching	
Unit 5: Technical impacts of DGs *(06Hrs)*							
Transmission systems, Distribution systems, De-regulation – Impact of DGs upon protective relaying – Impact of DGs upon transient and dynamic stability of existing distribution systems.	CO 4	***PO1. PO2***	***PSO 1,PSO3***	1.1 1.2	1.1.2 1.2.1	ICT, classroom teaching	
Unit 6: Economic and control aspects of DGs *(6Hrs)*							
Market facts, issues and challenges – Limitations of DGs – Voltage control techniques, Reactive power control, Harmonics, Power quality issues – Reliability of DG based systems – Steady state and Dynamic analysis.	CO 2	***P03***	***PSO 1,PSO3***	3.1	3.1.1		

Text Books:

1. Renewable Energy- Power for a sustainable future, third edition, Edited by Godfrey Boyle, Oxford University Press, 2013.
2. H. Lee Willis, Walter G. Scott , ‘Distributed Power Generation – Planning and Evaluation’, Marcel Decker Press, 2000.
3. M.Godoy Simoes, Felix A.Farret, ‘Renewable Energy Systems – Design and Analysis with Induction Generators’, CRC press.
4. Amirnaser Yezdani, and Reza Iravani, “Voltage Source Converters in Power Systems:
5. Modeling, Control and Applications”, IEEE John Wiley Publications, 2009.
6. Robert Lasseter, Paolo Piagi, ‘ Micro-grid: A Conceptual Solution’, PESC 2004, June 2004.
7. Microgrids: Architectures and Control, Nikos Hatziargyriou (Editor), ISBN: 978-1-118-72068-4, 340 pages, December 2013, Wiley-IEEE Press Microgrids and Active Distribution Networks, S. Chowdhury, S.P. Chowdhury and P. Crossley, The Institution of Engineering and Technology, London, U.K, 2009.
8. F. Katiraei, M.R. Iravani, ‘Transients of a Micro-Grid System with Multiple Distributed Energy Resources’, International Conference on Power Systems Transients (IPST’05) in Montreal, Canada on June 19-23, 2005.

Reference Books:

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

E-sources: NPTEL course on “Distributed Generation and Micro-grid”

Course Code: 20PEE110L	***Software Technologies in Power System***	***Total credits: 02***
Teaching Scheme		***Evaluation Scheme***
Theory : --Hrs/week		***CA: 25 Marks***
Practical: 2Hr/week		***Pract/Oral: 25 Marks***
Course Objectives	1. To provide comprehensive idea about different software used in power system field. 2. To learn basics, library & tools in software. 3. To learn & apply this software's in solving power system problems.	
Course Outcomes	Students will be able to 1. Understand the basics, library & tools in software 2. Use software & model simple examples. 3. Demonstrate the skills required in software. 4. Apply library & tools functions in solving problems. 5. Analyse solution using software.	
Pre-requisites	***Engg. Drawing, Electrical circuit, Network analysis, Power system***	
Course Type	***Program Core Course***	
Course Contents		

Unit	***PO Mapping***	***PSO Mapping***	***Teaching Methodology***	***CO Mapping***	***Competency***	***PI***
Unit1: MATLAB Practices:						
Programmes and related applications like Formation of Matrices, valuation of expressions etc.**Programme Design**: Logic Operators, Branches, Solution of quadratic equation and advance plotting features and related applications like time response of electrical networks etc. **Loops and related applications**: Calculations of RMS value, average value, Geometric mean, Harmonic mean.	***PO1, PO3 PO 5***	***PSO1***	***Explanation by Qualitative Discussion & PPT & Practices***	**CO 1 CO 2 CO 3**	**1.3 3.1 5.1**	**1.3.1 3.1.1 5.1.1**
Unit 2: SIMULINK						
Simulink tools, learning environment and creating MAT Files. Drawing simulink model to simulate different power system models.	***PO1, PO3 PO 5***	***PSO1***	***Explanation by Qualitative Discussion & PPT & Practices***	**CO 1 CO 2 CO 3**	**1.3 3.1 5.1**	**1.3.1 3.1.1 5.1.1**
Unit 3: Electrical CADElectrical schematic drafting:						
Specialized features such as Trim	***PO1,***	***PSO1***	***Explanation***	**CO 1**	**1.3**	**1.3.1**

Wire, Scoot and Align Components bus-wiring to a three-phase circuit drawing, three-phase motor with automatic connections and fuses , wire numbers and components and scoot wire numbers and components when editing, Adjust wire crossings **panel layout drawing:** panel components to represent schematic pushbuttons and selector switches, Add nameplates with descriptions for each panel door component, Balloon each of the pushbuttons and the switch with the same balloon number as the parts list	***PO3 PO 5***		***by Qualitative Discussion & PPT & Practices***	**CO 2 CO 3 CO 4**	**3.1 5.1**	**3.1.1 5.1.1**
Unit 4: Power System CAD						
Creating a small simulation case using PSCAD, Building the power system, Data entry , Results, graphs, plots, and meters ,Interactive control features of PSCAD (sliders, push buttons, dials and switches) Representation of power system components, power electronic and control system elements, Transient Studies	***PO1, PO3 PO 5***	***PSO1***	***Explanation by Qualitative Discussion & PPT & Practices***	**CO 1 CO 2 CO 3 CO 5**	**1.3 3.1 5.1**	**1.3.1 3.1.1 5.1.1**
UNIT 5: ETAP (Electrical Transient and Analysis Program)						
design, simulation, operation, and results in power flow studies, AC systems, DC systems etc.	***PO1, PO3 PO 5***	***PSO1***	***Explanation by Qualitative Discussion & PPT & Practices***	**CO 1 CO 2 CO 3**	**1.3 3.1 5.1**	**1.3.1 3.1.1 5.1.1**

TEXT BOOKS:

1. Getting Started with MATLAB by Rudra Pratap
2. AUTOCAD ELECTRICAL 2016 BLACK BOOK by Gaurav Verma
3. User guide of PSCAD by Manitoba Hydro International Research Centre

REFERENCE BOOKS:

1. Stephen J. *Chapman, "*MATLAB (r) Programming for Engineers" Cengage Learning India 2013
2. Power Systems Analysis Illustrated with MATLAB and ETAP by Hemchandra M. Shertukde

E-sources: Online course on "MATLAB" by Mathworks
Online course on "E Cad" by Autodesk
Online course on "PSCAD" by Manitoba Hydro International & Nayak Corporation
Online course on "ETAP" by ETAP Corporation

Course Code: 20PEE111L	Power System Lab I	Total credits: 02
Execution Scheme		***Evaluation Scheme***
Practical :2 Hrs/week		***CA: 25 Marks*** ***Practical Viva: 25 Marks***

Lab outcomes	1- Student would be able to simulate, analyse power system Behaviour using software simulator/hardware 2-Student would be able to simulate, analyse the performance of power system using PSCAD, MATLAB, Simulink etc 3-Student would be able to analyze the different types of power system models & analysis.
Course Contents	The course will cover minimum two Practicals on each subject course in Semester I depending on the subject course contents and simulation, practice needed in the course. The practicals will be performed on different software like PSCAD, ETAP, SIMULINK & MATLAB etc.

SEMESTER II

*Course Code : **20PEE201D***	**Advanced Power system Protection**	***Total credits: 04***
Teaching Scheme		***Evaluation Scheme***
		CA : 20 Marks
Theory: 03Hrs/week		***Mid sem: 20Marks***

Course Objectives	1.To understand the importance of static relays. 2. To understand the advances in protection
Course Outcomes	Students will be able to 1.Understand philosophy of various relays used in power system protection. 2.Understand basic principle of digital relaying.
Pre-requisites	***Switchgear and protection***
Course Type	***Program Elective Course***
Course Contents	

Unit No.	***CO Mapping***	***PO Mapping***	***PSO Mapping***	***Competency***	***PI***	***Teaching Methodology***	***Remark***
Unit 1: Static Relays							
advantages of static relays-Basic construction of static relays- Level Detectors- Replica impedance – Mixing circuits- General equation for two input phase and amplitude comparators- Duality between amplitude and phase comparators. Amplitude Comparators: Circulating current type and opposed voltage type- rectifier bridge comparators, Direct and Instantaneous comparators The need for modelling of power system, different areas of power system analysis. Models of non-electrical components like	***CO 1***	***PO1 PO2 PO3 PO4 PO5***	***PSO1 PSO3***	1.3, 1.4 2.4 3.1 4..1 5.1	***1.3.1 1.4.1 2..4.4 3.1.1 4.1.1 5.1.2***	***Interactive teaching with the help of ICT***	
Unit 2 : Phase Comparators							
Coincidence circuit type- block spike phase comparator, techniques to measure the period of coincidence-Integrating type-Rectifier and Vector product type- Phase comparators. STATIC OVER CURRENT RELAYS: Instantaneous over-current relay-Time over-current relays basic principles –definite time and Inverse definite time over-current relays.	***CO1***	***PO1 PO2 PO3 PO4 PO5***	***PSO1 PSO3***	1.3, 1.4 2.4 3.1 4..1 5.1	***1.3.1 1.4.1 2..4.4 3.1.1 4.1.1 5.1.2***	***Interactive teaching with the help of ICT***	
Unit 3 : Static Differential Relays							
Analysis of Static Differential Relays – Static Relay schemes – Duo bias transformer differential protection – Harmonic restraint relay. STATIC DISTANCE RELAYS: Static impedance reactance–MHO and angle impedance relay-sampling comparator –realization of reactance and	***CO1***	***PO1 PO2 PO3 PO4 PO5***	***PSO1, PSO3***	1.3, 1.4 2.4 3.1 4..1 5.1	***1.3.1 1.4.1 2..4.4 3.1.1 4.1.1 5.1.2***	***Interactive teaching with the help of ICT***	

out of step tripping and blocking relays-effect of line and length and source impedance on distance relays.							
Unit 5: Microprocessor based Protective relay							
(Block diagram and flowchart approach only)- Over current relays– impedance relays- directional relay-reactance relay .Generalized mathematical expressions for distance relays- measurement of resistance and reactance –MHO and offset MHO relays- Realization of MHO characteristics- ealization of offset MHO characteristics -Basic principle of Digital Relays	***CO2***	***PO1 PO2 PO3 PO4 PO5***	***PSO1 PSO3***	*1.3, 1.4 2.4 3.1 4..1 5.1*	***1.3.1 1.4.1 2..4.4 3.1.1 4.1.1 5.1.2***	***Interactive teaching with the help of ICT***	

computer relaying.

Text Books :

1. Power system protection and Switch gear, Badri Ram and D.N.Vishwakarma, "TMH publication New Delhi 1995.

Reference Books :

1 Static relays, T.S.Madhava Rao, TMH publication, second edition 1989.

2. Protection and Switchgear, Bhavesh Bhalja, R. P. Mahesheari, Nilesh G. Chothani, Oxford University Press.

3. Electrical Power System Protection, C. Christopoulos and A. Wright, Springer International.

E-Resources :

1.https://nptel.ac.in › courses

Course Code: 20PEE202D	*Power System Dynamics & Control*	*Total credits: 04*
Teaching Scheme		***Evaluation Scheme***
Theory : 4 Hrs/week		***CA: 20 Marks***
Tutorial: ---Hr/week		***Mid Sem: 20 Marks***
		End Sem: 60 Marks
Course Objectives	Student will be able to 1. Understand fundamental concepts & their classification in power system stability. 2. Explore voltage stability and islanding concepts in power stability studies 3. Impart knowledge on the design and application of Power system Stabilizer. 4. Extend basic stability analysis for multi machine system. 5. Analyze dynamics of synchronous generator connected to infinite bus.	
Course Outcomes	Students will be 1 Solve basic power system stability problems. 2 Interpret the design and working and of Power system Stabilizer. 3 Develop a model of synchronous generator connected to infinite bus for dynamic analysis 4 Apply and solve dynamic stability problems of synchronous generator connected to infinite bus. 5. Know basic stability analysis for multi machine system.	
Pre-requisites	Power system analysis	
Course Type	Main Core Course	
Course Contents		

Unit No.	***PO Mapping***	***PSO Mapping***	***Teaching Methodology***	***CO Mapping***	***Competency***	***PI***
Unit 1: Review of Classical Methods:						
System model, states of operation and system security, steady state stability, transient stability, simple representation of excitation control.	***PO1, PO2***	***PSO1***	***Explanation by Qualitative Discussion & PPT***	***CO 1***	***1.3 2.1***	***1.3.1 2.1.2***
Unit 2 Voltage Stability:						
Definition, factors affecting voltage instability and collapse, analysis and comparison of angle and voltage stability, analysis and comparison voltage instability and collapse, control of voltage instability.	***PO1, PO2, PO3 PO4***	***PSO1***	***Explanation by Qualitative Discussion *Problem Based***	***CO 1 CO 5***	***1.3 2.1 3.2 4.1***	***1.3.1 2.1.2 3.2.2 4.1.1***
Unit 3 Power System Stabilizers:						
Basic concepts of control signals in PSS, structure and tuning, field implementation, PSS design and application, future trends.	***PO1, PO2, PO3 PO4***	***PSO1***	***Explanation by Qualitative Discussion *Problem***	***CO 2***	***1.3 2.1 3.2 4.1***	***1.3.1 2.1.2 3.2.2 4.1.1***

			Based			
Unit 4 Multi-machine System- Fundamentals:						
Development of swing equation for coherent & non coherent group of multi machines, power flow in multi machine system, simplified multi machine model, Improved model of the system for linear load.	PO1, PO2	PSO1	Explanation by Qualitative Discussion	CO 4 CO 5	1.3 2.1	1.3.1 2.1.2
Unit 5 Dynamics of Synchronous Generator Connected to Infinite Bus:						
System model, simplified synchronous machine model, calculation of Initial conditions, system simulation, improved model of synchronous machine, inclusion of SVC model.	PO1, PO2, PO3 PO4	PSO1	Explanation by Qualitative Discussion	CO 4 CO 5	1.3 2.1 3.2 4.1	1.3.1 2.1.2 3.2.2 4.1.1
Unit 6 Analysis of Single Machine:						
Small signal analysis, applications of Routh-Hurwitz criterion, analysis of synchronizing and damping torque, state equation for small signal model.	PO1, PO2, PO3 PO4	PSO1	Explanation by Qualitative Discussion	CO 3 CO 4	1.3 2.1 3.2 4.1	1.3.1 2.1.2 3.2.2 4.1.1

TEXT BOOKS:

1. Power System Dynamics- K.R. Padiyar, B.S. Publications

2. Power System Dynamics Control – Prabha S. Kundur, IEEE Press , New York

REFERENCE BOOKS:

1. Power System Stability – E.W. Kimbark, IEEE press, N.Y, Vol.

2. Power System Control and Stability – Vol. – I – Anderson &Foud, IEEE Press, New York.

3. Power System Voltage Stability – C. W. Taylor., McGraw Hill International student edition

4. Distributed Generation Islanding – implication on power system dynamics performance. – R.A. Walling, N. W. Miller, Power Engineering Society, Summer Meeting, 2002, IEEE Publication, 25 July 2002, Vol. I, PP 92-96

E-sources: Online course on “Power System Dynamics & Conrol”

Course Code: *20PEE204E*	Power Sector Economics Restructuring and Regulation	Total credits: 03
Teaching Scheme		***Evaluation Scheme**
Theory : 3Hrs/week		CA : 20 Marks
Tutorial: 0Hr/week		Mid Sem: 20 Marks
		End Sem: 60 Marks

Course Objectives	1- To understand the need for restructuring the power sector and necessity of improving the technical and commercial efficiency. 2-To acquire the knowledge of the concepts of trading bulk electricity. 3- To analyze the open access to transmission as well as distribution of electricity.
Course Outcomes	Students will be able to- 1- Understand the current power sector in India. 2- Account the power Economics in consideration with the power Regulations. 3- Calculate various types of Tariffs, 4- Plan the restructuring of Power Sectors to match with current Market reforms. 5- Audit the Power pricing structure
Pre-requisites	Basic Electrical Engineering, Transmission and Distribution, Basics of Economics in Power System
Course Type	Program Core Course
Course Contents	

Unit No.	***CO Mapp i ng***	***PO Mapp i ng***	***PSO Mappi n g***	***Comp etency***	***PI***	****Teac hing Meth o dolog y***	***Remark***
Unit 1: Power Sector in India Introduction to various institutions in Indian Power sector such as CEA, Planning Commissions, PGCIL, PFC, Ministry of Power, state and central governments, REC, utilities and their roles. Critical issues / challenges before the Indian power sector, Need of regulation and deregulation of power industry. Conditions favoring deregulation in power sector.	***CO1***	***PO6 PO7***	***PSO1***	***6.1 6.2 7.1***	***6.1.1 6.2.1 7.1.1 7.1.2***	***Indus t rial Visits and Tutor i als , Smart Room Teac h ing***	
Unit 2: Power Sector Economics and Regulation Typical cost components and cost structure of the power sector, Concept of life cycle cost, annual rate of return, methods of calculations of Internal Rate of	**CO2**	**PO 1 PO 2 PO**	**PSO1**	**1.3 2.2**	**1.3.1 2.2.2**	**Smar t Room Teac h ing**	

		3					
Return(IRR) and Net Present Value(NPV) of project, Short term and long term marginal costs, Different financing options for the power sector, Role of regulation and evolution of regulatory commission in India.							
Unit 3: Power Tariff Consumer tariff structures and considerations, different consumer categories, telescopic tariff, Comparison of different tariff structures for different load patterns, Effect of renewable energy and captive power generation on tariff, Determination of tariff for renewable energy, Non-price issues in electricity restructuring.	CO3	PO1 PO2 PO3	PSO1, PSO2	1.1 2.1 3.1	1.1.1 1.1.2 2.1.1 3.1.1 3.1.2	Action Learni ng, Case Study	
Unit 4: Power sector restructuring and market reform Different industry structures and ownership and management models for generation, transmission and distribution, Competition in the electricity sector- conditions, barriers, different types, benefits and challenges Latest reforms and amendments, Different market and trading models / arrangements, open access, key market entities- ISO, Genco, Transco, Disco, Retailco,	CO4	PO4 PO5	PSO2	4.1 5.3	4.1.1 5.3.1	Peer to Peer, Brainstorming	
Unit 5: Power Sector Restructuring and Market Reform (Cont.) Power market types, Energy market, Ancillary service market, transmission market, Forward and real time markets, market power and exercising it and its effect on market operations Electricity price basics, Market operation, Market efficiency, gate closure, settlement process.	CO4	PO4 PO5	PSO2	4.1 5.3	4.1.1 5.3.1	Smart room Learning, Value Addition Course	
Unit 6: Power Pricing Structure Different methods of transmission pricing, Transmission cost allocation methods, Locational marginal price, firm transmission right. Transmission ownership and control, Transmission pricing model in India, concept of arbitrage in Electricity markets, game theory methods in Power System, Power purchase agreements (PPA); Power Exchange	CO5	PO1 PO2	PSO1	1.2 2.1	1.2.1 2.1.1	Group Assignment and Discussion	

Products; Structures Offered in Market; Market Clearing Mechanism with Hourly Bids; Congestion Management- Market Splitting; Market Clearing with Block Bids; Complexities; Paradoxically Rejected Bids; Solution Approach in power pricing.							

Text Books:

1. "Modern power system-the economic of restructuring", S. R. Panjarjoth, New Age International.
2. "Fundamentals of Power System Economics", D.S. Kirschen and G. Strbac, John Wiley & sons
3. "Electricity Economics Regulation and Deregulation", G. Rothwell and T Gómez, Wiley publication

Reference Books:

1. "Know Your Power", A citizens Primer on the Electricity Sector, Prayas Energy Group, Pune.
2. Deregulation in Power Industry, hand outs of CEP conducted by S.A. Khaparde

E-sources:

1. https://onlinecourses.nptel.ac.in/explorer

Course Code: 20PEE205E		*Total credits: 03*
Teaching Scheme	**Power System Automation**	*Evaluation Scheme*
Theory : 03 Hrs/week		*CA: 20 Marks*
Tutorial : 00 Hrs/week		*Mid Sem: 20 Marks*
Practical : 00 Hrs/week		*End Sem: 60 Marks*

Course Objective	5. To make the students understand the fundamentals of automation and various automation systems used in industry such as PLC, DCS, and SCADA 6. To introduce various advancements in the distribution systems 7. To understand the working of these systems and should be able to determine hardware and software requirements of PLC, DCS and SCADA. 8. To Assess the role of automation in Transmission/Distribution 9. To Planning for the distribution system and to understand the need of automation and control of distribution system.
Course Outcomes	Student will be able to 5. Define automation, it's importance, expectations from automation and applications in industry. 6. Plan for the distribution system and apply the automation and control techniques in the field. 7. Understand working of PLC, I/O modules of PLC, Programming languages and instructions of PLC, design PLC based application by proper ladder program. 8. To Assess the role of automation in Transmission/Distribution 9. To do Planning for the distribution system and to understand the need of automation and control of distribution system.
Pre-requisites	Basics of automation and control system engineering
Course Type	Program Core Course
Course Contents	

Unit No.	Co Mapping	PO Mapping	PSO Mapping	Competency	PI	Teaching Methodology	Remark
Unit 1 : Introduction *(07Hrs)*							
Purpose of automatic power control systems, Advantages , disadvantages, elements of automatic power control systems, automatic power control and controllers relays and relaying devices	CO 1	***PO1***	***PSO 1***	1.2	1.2.1	Interactive classroom teaching (ICT) classroom teaching	
Unit 2 : Distribution automation Basics *(07Hrs)*							
Distribution automation - Definitions - Project Planning - Communication, Sensors, Consumer Information Service- Geographical Information Systems –Automatic meter reading –Automation Systems	C02 ,C04,C05	***PO1, PO2***	***PSO 1,PSO3***	1.1 1.2 1.3 2.1	1.1.2 1.2.1 1.3.1 2.1.3	ICT, classroom teaching	
Unit 3: Distribution automation Advanced *(07Hrs)*							

Problems with existing distribution system, need for distribution automation, characteristics of distribution system, distribution automation, feeder automation , Supervisory Control and Data Acquisition (SCADA), Consumer Information systems (CIS), Geographical Information Systems (GIS)	C02 ,CO 3,C 04	***P01, PO2, PO3***	***PSO 1,PS O3***	1.1 1.2 1.3 2.1 3.1	1.1.2 1.2.1 1.3.1 2.1.3 3.1.1	ICT, classroom teaching	
Unit 4: . Operation and control *(06Hrs)*							
Operations environment of distribution networks, evolution of distribution management systems, basic distribution management system functions, basis of a real-time control system (SCADA), data acquisition, monitoring and event processing ,control functions, data storage, archiving, and analysis , hardware system configurations, SCADA system principles	C03	***PO1, PO2, PO3***	***PSO 1,PS O3***	1.1 1.2 1.3 2.1 3.1	1.1.2 1.2.1 1.3.1 2.1.3 3.1.1	ICT, classroom teaching	
Unit 5: Feeder automation *(06Hrs)*							
Losses in distribution systems, system losses and loss reduction, network reconfiguration, improvement in voltage profile, capacitor placement for reactive power compensation, algorithm for location of capacitor	C04 ,C0 5	***PO1. PO2***	***PSO 1,PS O2, PSO 3***	1.1 1.2 1.3 2.1	1.1.2 1.2.1 1.3.1 2.1.3	ICT, classroom teaching	
Unit 6: Substation automation *(6Hrs)*							
Definition, functions of substation automation state and trends of substation automation, intelligent affordable substation monitoring and control	C04 ,C0 5	***P03***	***PSO 1,PS O3***	3.1	3.1.1	ICT, classroom teaching	

Text Books:

1. Allen J.Wood and Wollenberg B.F., ‘Power Generation Operation and control’, John Wiley & Sons, Second Edition,1996.
2. Electric Energy systems Theory - An Introduction' Olle I Elgard, TMH Second Edition
3. Control and Automation of Electrical Power Distribution Systems (Power Engineering) James Northcote- Green James Northcote-Green, Taylor & Francis, 2007
4. James A Momoh, “Electric Power Distribution Automation Protection And Control” CRC Press Automation in Electrical power systems by,P.I.Zabolotny, MIR Publishers, Moscow
5. A Textbook of Electric Power Distribution Automation By Dr. M.K. Khedkar, Dr. G.M. Dhole, university science presss, new delhi2010

Reference Books:

1. Kirchmayer L.K., ‘Economic Control of Interconnected Systems’, John Wiley & Sons, 1959.
2. Sunil S. Rao, Switchgear and Protections, Khanna Publication
3. Gordan Clark, Deem Reynders, Practical Modem SCADA Protocols
4. Nagrath, I.J. and Kothari D.P., ‘Modern Power System Analysis’, TMH, New Delhi, 2006.
5. Stuart A Boyer: SCADA supervisory control and data acquisition

E-sources:

1. NPTEL course on “Power System Automation”

Course Code : 20PEE206E	***CONTROL DESIGN TECHNIQUES FOR POWER ELECTRONIC SYSTEMS***	*Total credits: 03*
Teaching Scheme		***Evaluation Scheme***
		CA : 20 Marks
Theory : 03 Hrs/week		***Mid sem: 20Marks***
Tutorial: -Hr/week		***End-Semester : 60 Marks***

Course Objectives	Student will be able to 1. Explore different control techniques in power electronics 2. Explore control in DC-DC converter 3. Impart knowledge on the design and application of controllers for different rectifiers 4. Extend various controllers for BLDC and Reluctance motors.
Course Outcomes	Students will able be 1. Recognize different control techniques 2. Model and analyze various closed loop controllers 3. Design controllers for different rectifiers and to analyze various modes of operation 4. Model and design of various controllers for BLDC and Reluctance motors. 5. design of compensators, controllers and observers
Pre-requisites	Power electronics
Course Type	Elective Core Course

Course Contents

Unit No.	***CO Mapping***	***PO Mapping***	***PSO Mapping***	***Competency***	***PI***	***Teaching Methodology***	***Remark***
Unit 1: Review of basic control theory							
Control design techniques such as P, PI,PID and lead lag compensator design. Review of state space control design approach – state feedback controller and observer design.	***CO1***	***PO1, PO2,PO3, PO4***	***PSO1***	***1.6 2.1 3.5***	***1.6.1 2.5.1 3.6.1***	***ICT TOOLS***	
Unit 2 Control of DC-DC converters.							
State space modeling of Buck, Buck-Boost, Cuk, Sepic, Zeta Converters. Equilibrium analysis and closed loop voltage regulations using state feedback controllers and sliding mode Controllers.	***CO1***	***PO1, PO2,PO3, PO4***	***PSO1***	***1.6 2.1 3.5***	***1.6.1 2.5.1 3.6.1***	***ICT TOOLS***	
Unit 3 Control of rectifiers.							
State space modeling of single phase and three phase rectifiers. State feedback controllers and observer design for	***CO1***	***PO1, PO2,PO3, PO4***	***PSO1***	***1.6 2.1 3.5 4.5***	***1.6.1 2.5.1 3.6.1 4.5.1***	***ICT TOOLS***	

output voltage regulation for nonlinear loads. Analysis of continuous and discontinuous mode of operation.							
Unit 4 Modelling of Brushless DC motors and its speed regulations							
State space model, sensorless speed control of BLDC motor and Sliding mode control design for BLDC motor. Modelling and control of switched reluctance motor	***CO1***	***PO1, PO2,PO3, PO4***	***PSO1***	***1.6 2.1 3.5 4.5***	***1.6.1 2.5.1 3.6.1 4.5.1***	***ICT TOOLS***	
Unit 5 Modeling of multi input DC-DC converters							
Its application to renewable energy. Output voltage regulation of Multi input DC-DC converter using state feedback controllers.	***CO1***	***PO1, PO2,PO3, PO4***	***PSO1***	***1.6 2.1 3.5 4.5***	***1.6.1 2.5.1 3.6.1 4.5.1***	***ICT TOOLS***	

TEXT BOOKS:

1. Bimal Bose, ‘Power electronics and motor drives’, Elsevier, 2006

REFERENCE BOOKS:

1. Sira -Ramirez, R. Silva Ortigoza, ‘Control Design Techniques in Power Electronics Devices’, Springer, 2006
2. Siew-Chong Tan, Yuk-Ming Lai, Chi Kong Tse, ‘Sliding mode control of switching Power Converters’, CRC Press, 2011
3. Ion Boldea and S.A Nasar, ‘Electric drives’, CRC Press, 2005

E-sources:

Online course on “Control Design Techniques For Power Electronic Systems”

Course Code: *20PEE207E*	**Electric & Hybrid Vehicle**		**Total credits: 03**
Teaching Scheme			***Evaluation Scheme**
Theory : 3 Hrs/week			CA: 20 Marks
Tutorial: --Hr/week			Mid Sem: 30 Marks
			End Sem: 50 Marks
Course Objectives	1-To create awareness about Electric vehicle. 2-To discuss electric and hybrid vehicle technology & their architecture. 3-To consider existing challenges for electric vehicles.		
Course Outcomes	Students would be able to 1-Realize need of EV. 2-Compare possible drive architecture. 3-Select appropriate energy storage system for EV. 4- Choose appropriate motors , convertors for EV and would identify communication protocol in EV. 5-Understand existing challenges for electric vehicles. .		
Pre-requisites	AC and DC motor and Power Electronics		
Course Type	Program Core Elective		
Course Contents			

Unit No.	*Co Mapping*	*PO Mapping*	*PSO Map ping*	*Compet ency*	*PI*	**Teaching Methodology*	Remark
UNIT:1 Introduction to Hybrid Electric Vehicles, Conventional Vehicles, Hybrid Electric Drive-trains.	***Co1***	***PO1*** ***PO6***	***PSO 1***	***1.1*** ***2.1***	***1.1.1*** ***2.1.3***	***PPT And Brainstor m ing***	
Unit:2 Design and simulation of Design and performance analysis of Electric Propulsion unit, Configuration and control of DC Motor drives, Induction Motor drives, Permanent Magnet Motor drives, switched reluctance motor	***Co2***	***PO2***	***PSO 1***	***1.1*** ***2.1***	***1.1.1*** ***2.1.3***	***Animation s & physical model***	
UNIT3: Design and performance analysis of Energy Storage Requirements in Hybrid and Electric Vehicles, Sizing the drive system, Design of a Hybrid Electric Vehicle , Energy Management Strategies.	***C03***	***PO2*** ***PO4***	***PSO 1***	***1.1*** ***2.1*** ***3.1***	***1.1.1*** ***2.1.3*** ***3.1.2***	***Brainstorming Comparati v e***	
UNIT-4 Modelling of Rectifier, charging techniques, fast charging techniques, charging time constant, charging bank, battery swap techniques,	***Co4***	***PO2*** ***PO4***	***PSO 1***	***1.1*** ***2.1*** ***3.1***	***1.1.1*** ***2.1.3*** ***3.1.2***	****Proble m based***	

UNIT-5 Design consideration of Ac- Dc and Dc- AC conversion on vehicle board, rectifier design , convertor design,	***C05***	***PO1***	***PSO 2***	***1.1 2.1 3.1***	***1.1.1 2.1.3 3.1.2***	Problem based	
UNIT-5 Battery swapping model ad Mathematical Model to describe vehicle Performance and latest communication protocols in EV	***Co5***	***P04***	***PSO 2***	***1.1 2.1 3.1 4.2***	***1.1.1 2.1.3 3.1.2 4.1.2***	Animations & physical model	

Text Books:

Iqbal Hussein, Electric and Hybrid Vehicle: Design Fundamentals, CRC Press

Reference Books:

1-James Larminie, John Lowry, " Electric Vehicle Technology: Explained, Willey

2- Mehrdad Ehsani, YimiGao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC press

E-sources:

NPTEL course on " Electric & Hybrid Vehicle"

Course Code : 20PEE208E	*Power Quality Assessment and Mitigation*	*Total credits: 03*
Teaching Scheme		*Evaluation Scheme*
		CA : 20 Marks
Theory : 03 Hrs/week		*MSE: 20 Marks*
		End-Semester Exam: 60

Course Objectives	4. To know different terms of power quality 5. To illustrate power quality issues. 6. To prepare mitigation of power quality issues
Course Outcomes	The Students will be able to 6. To Know the severity of power quality problems in distribution system 7. To construct study of characterization Power Quality and Power Quality Disturbances 8. To monitor the power quality with various equipment's. 9. To Assess the power quality of any system. 10. To Apply the mitigation techniques to reduce the adverse effects of power quality on system and equipment
Pre-requisites	***Basic Electrical Engineering, Electrical Machines & Electrical Power System***
Course Type	***1 – Program Core Course***
Course Contents	

Unit No.	***CO Mapping***	***PO Mapping***	***PSO Mapping***	***Compe-tency***	***PI***	***Teaching Methodology***	***Remark***
Unit 1: Introduction to Electrical Power Quality							
Introduction of the Power Quality (PQ) problem, Terms used in PQ: Voltage, Sag, Swell, Surges, Harmonics, over voltages, spikes, Voltage fluctuations, Transients, Interruption. Symptoms of poor power quality, Purpose of groundings, methods and problems.	***CO1 CO2***	***PO1 PO2***	***PSO1***	***1.2 1.5 2.5***	***1.2.1 1.5.1 2.5.1 2.5.3***	***Interactive teaching with the help of ICT***	
Unit -02: Voltage sag & Interruptions							
Definitions of voltage sag and interruptions. Voltage sags versus interruptions. Economic impact of voltage sag. Major causes and consequences of voltage sags. Voltage sag characteristics. Voltage sag assessment. Influence of fault location and fault level on voltage sag. Areas of vulnerability. Assessment of equipment sensitivity to voltage sags. Voltage sag requirements for computer equipment,	***CO2 CO3***	***PO1 PO2 PO5***	***PSO1***	***1.2 1.5 2.5 5.5***	***1.2.1 1.5.1 2.5.1 2.5.3 5.5.2***	***Interactive teaching with the help of ICT***	

CBEMA, ITIC, SEMI F 42 curves. Representation of the results of voltage sags analysis. Voltage sag indices. Mitigation measures for voltage sags, such as UPS, DVR, SMEs, CVT etc., utility solutions and end user solutions.							
Unit 3 : Waveform Distortion							
Definition of harmonics, interharmonics, subharmonics. Causes and effect of harmonics. Voltage versus current distortion. Overview of Fourier analysis. Harmonic indices. A.C. quantities under non-sinusoidal conditions. Triplen harmonics, characteristics and noncharacteristics harmonics. Harmonics series and parallel resonances. Consequences of harmonic resonance. K-rated transformer. Principles for controlling harmonics. Reducing harmonic currents in loads. Harmonic study procedure. Computer tools for harmonic analysis. Locating sources of harmonics. Harmonic filtering, passive and active filters. Modifying the system frequency response. IEEE Harmonic standard 519-1992	***CO3 CO4***	***PO1 PO2 PO3 PO4 PO5***	***PSO1 PSO2 PSO3***	***1.2 1.5 2.5 3.5 4.5 5.5***	***1.2.1 1.5.1 2.5.1 3.5.1 4.5.1 5.5.2***	***Project Based or Activity Teaching***	
Unit 4:Power Quality Monitoring							
Need of power quality monitoring and approaches followed in power quality monitoring. Power quality monitoring objectives and requirements. Initial site survey. Power quality Instrumentation. Selection of power quality monitors, selection of monitoring location and period. System wide and discrete power quality monitoring. Setting thresholds on monitors, d data collection and analysis. Selection of transducers. Harmonic monitoring, transient monitoring, event recording and	***CO5 CO4***	***PO1 PO2 PO3 PO5***	***PSO1 PSO2 PSO3***	***1.2 1.5 2.5 3.5 5.5***	***1.2.1 1.5.1 2.5.1 2.5.3 3.5.1 5.5.2***	***Project Based or Activity Teaching***	

flicker monitoring.							
Unit 5: Power Quality Considerations in Industrial Power Systems:							
Voltage sag – equipment behavior of Power electronic loads, induction motors, synchronous motors, computers, consumer electronics, adjustable speed AC drives and its operation. Mitigation of AC Drives, adjustable speed DC drives and its operation, mitigation methods of DC drives.	***CO5 CO3***	***PO1 PO3 PO4***	***PSO1 PSO2 PSO3***	***1.2 1.5 2.5 3.5***	***1.2.1 1.5.1 2.5.1 2.5.3 3.5.1***	***Project Based or Activity Teaching***	
Unit 6: Power Quality Assessment and Mitigation							
Power Quality assessment, Power quality indices and standards for assessment disturbances, waveform distortion, voltage and current unbalances. Power assessment under waveform distortion conditions. Power quality state estimation, State variable model, observity analysis, capabilities of harmonic state estimation. Test systems. Mitigation techniques at different environments	***CO3 CO4 CO5***	***PO1 PO3 PO4***	***PSO1 PSO2 PSO3***	***1.2 1.5 2.5 3.5***	***1.2.1 1.5.1 2.5.1 2.5.3 3.5.1***	***Project Based or Activity Teaching***	

Text Books :

5. Math H J Bollen "Understanding Power Quality Problems", IEEE Press.
6. R.C. Dugan, M.F. Mc Granaghan and H.W. Beaty, "Electric Power Systems Quality." New York: McGraw-Hill. 1996
7. Power system quality assessment - J. Arrillaga, M.R. Watson, S. Ghan, John Wiley and sons.

Reference Books :

1. G.T. Heydt, 'Electric Power Quality', 2nd Edition. (West Lafayette, IN, Stars in a Circle Publications, 1994).
2. Power Quality VAR Compensation in Power Systems, R. Sastry Vedam Mulukutla S. Sarma, CRC Press.
3. A Ghosh, G. Ledwich, Power Quality Enhancement Using Custom Power Devices. Kluwer Academic, 2002

E-Resources :

3. https://nptel.ac.in/courses/108106025/ (NPTEL Power Quality Improvement Technique)
4. https://nptel.ac.in/courses/108107157/ (NPTEL Power Quality Improvement)

<table>
<tr><td colspan="3">Course Code : 20PEE209E</td><td colspan="3" rowspan="2">ANN& Its applications in Power System</td><td colspan="2">Total credits: 03</td></tr>
<tr><td colspan="3">Teaching Scheme</td><td colspan="2">Evaluation Scheme</td></tr>
<tr><td colspan="4"></td><td colspan="4">CA: 1 and CA:2 (Min.10 marks each):20</td></tr>
<tr><td colspan="4">Theory : 03 Hrs/week</td><td colspan="4">Mid sem: 20Marks</td></tr>
<tr><td colspan="4">Tutorial: -Hr/week</td><td colspan="4">End-Semester : 60 Marks</td></tr>
<tr><td>Course Objectives</td><td colspan="7">1. To learn various theoretical aspects of four major approaches to artificial intelligence namely, Artificial Neural Network, Fuzzy Logic, Genetic Algorithm and Expert System.
2. To study methodologies for applying AI techniques to the problems in the fields of electrical engineering.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">Students will be able to
1. Differentiate between Algorithmic based methods and knowledge based methods.
2. Use the soft computing techniques for power system problems.
3. Use appropriate AI framework for solving power system problems.
4. Apply GA to power system optimization problems.</td></tr>
<tr><td>Pre-requisites</td><td colspan="7"></td></tr>
<tr><td>Course Type</td><td colspan="7"></td></tr>
<tr><td colspan="8">Course Contents</td></tr>
<tr><td>Unit No.</td><td>CO Mapping</td><td>PO Mapping</td><td>PSO Mapping</td><td>Competency</td><td>PI</td><td>Teaching Methodology</td><td>Remark</td></tr>
<tr><td colspan="8">Unit 1 : INTRODUCTION</td></tr>
<tr><td>Artificial-Neural Networks (ANN) definition and fundamental concepts – Biological neural networks – Artificial neuron – activation functions – setting of weights – typical architectures – biases and thresholds – learning/training laws and algorithms. Comparison with deterministic methods Aims objectives of artificial intelligence and current state of the art. Perceptron architectures, ADALINE and MADLINE-linear separability-XOR function.</td><td>CO1,CO2</td><td>PO1,PO2</td><td>PSO1</td><td>1.2
2.1</td><td>1.2.1
2.1.3</td><td>ICT AND Classroom discussion
.</td><td></td></tr>
</table>

Unit 2 : ANN PARADIGMS							
ADALINE – feed forward networks – Back Propagation algorithm- number of hidden layers – gradient decent algorithm – Radial Basis Function (RBF) network. Kohonen‟s self organizing map (SOM), Learning Vector Quantization (LVQ) and its types – Functional Link Networks (FLN) – Bidirectional Associative Memory (BAM) – Hopfield Neural Network. Applications of AI to power systems like alarm processing, condition monitoring, protective relaying etc.	***CO1,CO2***	***PO2,PO3, PO4***	***PSO2,PSO3***	***2.2 3.2 4.3***	***2.2.3 3.2.1 4.3.2***	***ICT AND Classroom discussion***	
Unit 3 : CLASSICAL AND FUZZY SETS							
Introduction to classical sets- properties, Operations and relations; Fuzzy sets, Membership, Operations, Properties, Fuzzy relations, Cardinalities, Membership functions	***CO1,CO2***	***PO1,PO2***	***PSO1***	***1.3 2.3***	***1.3.1 2.3.2***	***ICT AND Classroom discussion***	
Unit 4: FUZZY LOGIC CONTROLLER (FLC)							
Fuzzy logic system components: Fuzzification, Inference engine (development of rule base and decision making system), Defuzzification to crisp sets- Defuzzification methods.	***CO1,CO2***	***PO2,PO3, PO4***	***PSO1,PSO2***	***2.4 3.3 4.3***	***2.4.1 3.3.1 4.3.4***	***ICT AND Classroom discussion***	

Unit 5: APPLICATIONS OF ANN AND FLC							
Applications of ANN- Load flow, Economic load dispatch, Load forecasting, PWM controllers, selected harmonic elimination- PWM space vector- PWM vector controlled drive- Speed estimation and flux estimation of induction motor. Applications of FLC- Load frequency control- Single area and two area systems- Speed control of DC motor.	***CO2,CO3***	***PO4,PO5***	***PSO2,PSO3***	***4.3 5.1***	***4.3.2 5.1.2***	***ICT AND Classroom discussion***	

Text Books :

1. Neural Networks, Fuzzy logic, Genetic algorithms: synthesis and applications by Rajasekharan and pai – PHI Publication.
2. Fuzzy logic with Fuzzy Applications – T.J Ross – Mc Graw Hill Inc, 1997.
3. Kevin Warwick, "Arthur Ekwue and Raj Aggarwal; "Artificial Intelligence Techniques in Power Systems". The Institution of Electrical Engineers, London, 1989.

Reference Books :

1. Neural Networks: A comprehensive Foundation – Simon Haykins, Pearson Edition, 2003.
2. Yegnanarayana B, "Artificial Neural Networks", prentice hall of India Private Ltd., New Delhi, 1999.
3. Zurada, J.M, Introduction to Artificial Neural Systems‟, Jaico publishing house, Bombay, 1992.
4. Zimmermann, H.J.Fuzzy set theory and its applications‟, Allied publishers limited, Madras, 2001.
5. T.S. Dillon and M.A Laughtonm; "Expert system applications in power systems", Prentice Hall International, 1992.
6. Bart Kosko, "Neural networks and Fuzzy Systems", Prentice Hall of India, 1990.

E-Resources :

IEEE Website

Course Code : 20PEE210E	Distribution System Planning And Automation	Total credits: 03
Teaching Scheme		Evaluation Scheme
		CA : 20 Marks
Theory : 03 Hrs/week		MSE: 20 Marks
		End-Semester Exam: 60

Course Objectives	1. To know different terms Distribution system 2. To prepare protections schemes for distribution system. 3. To prepare the automation algorithms for distribution system.
Course Outcomes	The Students will be able to 1. To Understand and distinguish characteristics of distribution systems from transmission systems 2. To design, analyse and evaluate distribution system design based on forecasted data. 3. Identify and select appropriate sub–station location 4. Design and evaluate a distribution system for a given geographical service area from alternate design alternatives. 5. To understand automation and protection schemes at substations.
Pre-requisites	***Basic Electrical Engineering, Electrical Machines & Electrical Power System***
Course Type	***1 – Program Core Course***

Course Contents

Unit No.	***CO Mapping***	***PO Mapping***	***PSO Mapping***	***Competency***	***PI***	***Teaching Methodology***	***Remark***
Unit 1: Distribution System Planning & Load Characteristics::							
Planning and forecasting techniques , Present and future , Role of computers. Load Characteristics: Definitions , Load forecasting , methods of forecast , regression analysis , correlation analysis and time series analysis , Load management , tariffs and metering of energy.	***CO1***	***PO1 PO2***	***PSO1***	***1.2 1.5 2.5***	***1.2.1 1.5.1 2.5.1 2.5.3***	***Interactive teaching with the help of ICT***	
Unit -02: Distribution Transformers & Substation							
Distribution	***CO2***			***1.2***	***1.2.***	***Interactive***	

Transformers: Types , Three phase and single phase transformers , connections , Dry type and self-protected type transformers , regulation and efficiency. Distribution substations–Bus schemes description and comparison of switching schemes Substation location and rating. Types of feeders , voltage levels , radial type feeders.	***CO3***	***PO1*** ***PO2*** ***PO5***	***PSO1***	***1.5*** ***2.5*** ***5.5***	***1*** ***1.5.1*** ***2.5.1*** ***2.5.3*** ***5.5.2***	***teaching with the help of ICT***	
Unit 3 : Voltage Drop And Power Loss Calculations							
Three phase primary lines , Copper loss , Distribution feeder costs , Loss reduction and Voltage improvement in rural networks.	***CO3*** ***CO4***	***PO1*** ***PO2*** ***PO3*** ***PO4*** ***PO5***	***PSO1*** ***PSO2*** ***PSO3***	***1.2*** ***1.5*** ***2.5*** ***3.5*** ***4.5*** ***5.5***	***1.2.1*** ***1.5.1*** ***2.5.1*** ***3.5.1*** ***4.5.1*** ***5.5.2***	***Project Based or Activity Teaching***	
Unit 4: Capacitors In Distribution Systems							
Effects of series and shunt capacitors , justification for capacitors , Procedure to determine optimum capacitor size and location	***CO4*** ***CO5***	***PO1*** ***PO2*** ***PO3*** ***PO5***	***PSO1*** ***PSO2*** ***PSO3***	***1.2*** ***1.5*** ***2.5*** ***3.5*** ***5.5***	***1.2.1*** ***1.5.1*** ***2.5.1*** ***2.5.3*** ***3.5.1*** ***5.5.2***	***Project Based or Activity Teaching***	
Unit 5: Distribution System Protection:							

Basic definitions, types of over current protection devices. Objective of distribution system protection. Grounding: Grounding system, earth and safety , nature and sizes of earth electrodes , design , earthing schemes.	***CO3 CO4 CO5***	***PO1 PO3 PO4***	***PSO1 PSO2 PSO3***	***1.2 1.5 2.5 3.5***	***1.2.1 1.5.1 2.5.1 2.5.3 3.5.1***	***Project Based or Activity Teaching***	
Unit 6: Distribution System Automation							
Reforms in power sector, Improvement Methods, Reconfiguration , Reinforcement, Automation, Communication systems, Sensors, Automation systems, Basic architecture of Distribution automation system, software and open architecture, RTU and Data communication, SCADA requirement and application functions, GIS/GPS based mapping of Distribution networks– Communication protocols for Distribution	***CO2 CO5***	***PO1 PO3 PO4***	***PSO1 PSO2 PSO3***	***1.2 1.5 2.5 3.5***	***1.2.1 1.5.1 2.5.1 2.5.3 3.5.1***	***Project Based or Activity Teaching***	

systems, Integrated sub, station metering system, Revenue improvement, issues in multi–year tariff and availability based tariff.							

Text Books :

8. Turan Gonen, “Electrical Power Distribution Engineering”, McGraw-Hill.
9. A. S. PABLA, “Electric Power Distribution”, TMH,2000..
10. R.C. Dugan, M.F. Mc Granaghan and H.W. Beaty, “Electric Power Systems Quality.” New York: McGraw-Hill. 1996
11. Power system quality assessment - J. Arrillaga, M.R. Watson, S. Ghan, John Wiley and sons.

Reference Books :

4. Colin Bayliss, “Transmission and Distribution Electrical Engineering”, Butterworth Heinemann, 1996
5. Pansini, “Electrical Distribution Engineering”
6. E. Lakervi& E. J. Holmes, “Electricity Distribution Network Design”, 2ndEdition, Peter Peregrimus Ltd.
7. Dhillan B. S., ”Power System Reliability, Safety and Management” , An Arbor Sam 1981

E-Resources :

5. https://nptel.ac.in/courses/108107112/ (NPTEL Electrical Distribution System Analysis)

Course Code: 20PEE211E	Smart Grid Technologies	Total credits: 03
Teaching Scheme		***Evaluation Scheme***
Theory : 3 Hrs/week		***CA: 20 Marks***
Tutorial: ---Hr/week		***Mid Sem: 20 Marks***
		End Sem: 60 Marks

Course Objectives	Student will be able to 1. Learn different evolution in power grid 2.Know about feasibility of different energy management systems and their integration in power system 3. Learn new concepts in distribution management systems 4. Explore different communication & networking in smart grid.
Course Outcomes	Students will be 1. Explain the fundamental electric grid 2. Analyze energy management system 3. Get acquainted with the smart resources, smart meters and other smart devices. 4. Describe how modern power distribution system functions. 5. Identify suitable communication networks for smart grid applications
Pre-requisites	Fundamentals of Power Distribution Systems
Course Type	***Elective Core Course***
Course Contents	

Unit No.	***PO Mapping***	***PSO Mapping***	***Teaching Methodology***	***CO Mapping***	***Competency***	***PI***
Unit 1: Introduction						
Evolution of Electric Grid, Smart Grid Concept - Definitions and Need for Smart Grid –Functions – Opportunities – Benefits and challenges, Difference between conventional & Smart Grid, Technology Drivers.	***PO1, PO2, PO3,***	***PSO1***	***Explanation by Qualitative Discussion *PPT***	***CO 1***	***1.3 2.1 3.1***	***1.3.1 2.1.1 3.1.1***
Unit 2: Energy Management System (EMS)						
Smart substations - Substation Automation - Feeder Automation, SCADA – Remote Terminal Unit – Intelligent Electronic Devices – Protocols, Phasor Measurement Unit –Wide area monitoring protection and control, Smart integration of energy resources – Renewable, intermittent power sources – Energy Storage.	***PO1, PO2, PO3***	***PSO1***	***Explanation by Qualitative Discussion *Problem Based***	***CO 2 CO 3***	***1.3 2.1 3.1***	***1.3.1 2.1.1 3.1.1***
Unit 3: Distribution Management System (DMS)						
Volt / VAR control – Fault Detection, Isolation and Service Restoration, Network Reconfiguration, Outage management System, Customer	PO1, PO2, PO3 PO4	PSO1	Explanation by Qualitative Discussion	CO 3 CO 4	1.3 2.1 3.1 4.1	1.3.1 2.1.1 3.1.1 4.1.1

Information System, Geographical Information System, Effect of Plug in Hybrid Electric Vehicles.			*Problem Based			
UNIT4: Introduction to Smart Meters						
Advanced Metering infrastructure (AMI), AMI protocols – Standards and initiatives, Demand side management and demand response programs, Demand pricing and Time of Use, Real Time Pricing, Peak Time Pricing.	PO1, PO2,PO3 PO4	PSO1	Explanation by Qualitative Discussion	CO 3	1.3 2.1 3.1 4.1	1.3.1 2.1.1 3.1.1 4.1.1
UNIT 5: Elements of communication and networking						
architectures, standards, PLC, Zigbee, GSM, BPL, Local Area Network (LAN) - House Area Network (HAN) - Wide Area Network (WAN) - Broadband over Power line (BPL)	PO1, PO2,PO3 PO4	PSO1	Explanation by Qualitative Discussion	CO 5	1.3 2.1 3.1 4.1	1.3.1 2.1.1 3.1.1 4.1.1
UNIT 6: Other networking						
IP based Protocols, Basics of Web Service and CLOUD Computing, Cyber Security for Smart Grid.	PO1, PO2,PO3 PO4	PSO1	Explanation by Qualitative Discussion	CO 5	1.3 2.1 3.1 4.1	1.3.1 2.1.1 3.1.1 4.1.1

TEXT BOOKS:

1. Stuart Borlase ‘Smart Grid: Infrastructure, Technology and Solutions’, CRC Press 2012.

REFERENCE BOOKS:

1. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, ‘Smart Grid: Technology and Applications’, Wiley, 2012.

2. Mini S. Thomas, John D McDonald, ‘Power System SCADA and Smart Grids’, CRC Press, 2015

3. Kenneth C.Budka, Jayant G. Deshpande, Marina Thottan, ‘Communication Networks for Smart Grids’, Springer, 2014.

E-sources: Online course on “Smart Grid Technologies”

Course Code: 20PEE212E	***Digital Controllers in Power Electronics Applications***	*Total credits: 03*
Teaching Scheme		***Evaluation Scheme***
		Mid Sem: 20Marks
Theory: 03 Hrs/week		***Simulation Assignment: 20 Marks***
Tutorial: --Hr/week		***End-Semester: 60***

Course Objectives	1. To understand the working of digital controllers. 2. To analyse the operation of Digital Controllers. 3.To apply the knowledge of Digital Controller for power electronics applications.
Course Outcomes	Students will be able to 1.Understand working of Digital Controller. 2.Design Digital Controllers. 3. Understand microcontroller-based power electronic applications. 4. Develop and design application controller circuit of power electronics. 5. Perform different analysis on circuit simulation.
Pre-requisites	**Power Electronics, Advance Power Converters**
Course Type	***Elective Subject***

Course Contents

Unit No	*CO Mapping*	*PO Mapping*	*PSO Mapping*	*Competency*	*PI*	**Teaching Methodology*	*Remark*
Unit 1: Control System Overview							
Feedback and Feed-forward control, Right Half Plane Zero, Gain margin and Phase Margin, Stability, Analysis and Transfer function of P, PI and PID controllers and its effects. Voltage mode control, Peak Current mode Control, Average Current mode Control for Converters – Need, Discussion.		***PO1,2***	***PSO1, PSO2, PSO3***	***1.2 1.5 2.1 2.8 3.5***	***1.2.1 1.6.1 2.5.1 2.5.2 2.8.2***	***Interactive teaching with the help of ICT***	
Unit 2: Digital Controller Design							
Digital controller design via classical techniques, such as lead, lag, lag-lead, and PID controllers. Direct digital design techniques. Introduction to modern control techniques, based on State Space models, pole-placement and observers.	***CO1 CO2***	***PO1,2,3***	***PSO1, PSO2***	***1.2 1.5 2.1 2.8 3.7***	***1.2.1 1.6.1 2.5.1 2.5.2 2.8.2 3.7.1***	***Interactive teaching with the help of ICT***	
Unit 3: Microcontroller for Converters							
Micro Controllers for Converter Control Application, Interface Modules for Converter Control – A/D, Capture, Compare and PWM, Analog Comparators for instantaneous over current detection, interrupts, Discrete PI and PID equations, Algorithm for	***CO1 CO2***	***PO1,2,3***	***PSO1, PSO2***	***1.2 1.5 2.1 2.8 3.7***	***1.2.1 1.6.1 2.5.1 2.5.2 2.8.2 3.7.1***	***Interactive teaching with the help of ICT***	

PI and PID implementation, Example Code for PWM generation.							
Unit 4: Microcontroller Applications for Power Converters							
microcontroller-typical applications-DC motor speed control, speed measurement, Temperature control, stepper motor control, PID control.	***CO2 CO3***	***PO1,2,3***	***PSO1, PSO2***	***1.2 1.5 2.1 2.8 3.7***	***1.2.1 1.6.1 2.5.1 2.5.2 2.8.2 3.7.1 4.4.1***	***Interactive teaching with the help of ICT***	
Unit 5: Digital Controller Design for Buck Converter							
Power circuit transfer function and bode plot, PI controller bode plot, combined bode plot with required Gain and Phase margins, Implementation of Digital controller.	***CO2 CO3***	***PO1,2,3, 4,5***	***PSO1, PSO2, PSO3***	***1.2 1.5 2.1 2.8 3.7 4.4 5.5***	***1.2.1 1.6.1 2.5.1 2.5.2 2.8.2 3.7.1 4.4.1 5.5.1***	***Interactive teaching with the help of ICT***	
Unit 6: Special Processor for Power Converters.							
PID Controllers, DSP Controller, Fuzzy Controller, Neural Network Controller for Different Power Electronic Converters	***CO2 CO3***	***PO1,2,3***	***PSO1, PSO2***	***1.2 1.5 2.1 2.8 3.7***	***1.2.1 1.6.1 2.5.1 2.5.2***	***In Interactive teaching with the help of ICT***	

Textbooks:

1. Digital Power Electronics and Applications. By Feng Lin Luo, Hong Ye, and Muhammad Rashid.
2. J. Nagrath and M. Gopal, “Control Systems Engineering”, New Age International Publishers.

Reference Books:

Power Electronics: Converters, Applications and Design by Ned Mohan, Third Edition, Wiley India Publishers.

Sen M. Kuo, Woon Seng Gan, ‘Digital Signal Processors: Architecture, Implementation and Applications’, Pearson, 2005.

E-sources:

6. ***https://nptel.ac.in ›Advance power electronics courses***

Course Code: 20PEE213L		***Power System Lab II***	***Total credits: 02***
Execution Scheme			***Evaluation Scheme***
Practical :2 Hrs/week			***CA: 25 Marks*** ***Practical Viva: 25 Marks***
Lab outcomes	1- Student would be able to simulate, analyse power system Behaviour using software simulator/hardware 2- Student would be able to simulate, analyse the performance of power system using PSCAD, MATLAB, Simulink etc 3- Student would be able to analyze the different types of power system models & analysis.		
Course Contents	The course will cover minimum two Practicals on each subject course in Semester II depending on the subject course contents and simulation, practice needed in the course. The practicals will be performed on different software like PSCAD, ETAP, SIMULINK & MATLAB etc.		

SEMESTER III

Course Code : 20PEE301M	***Project Management and Intellectual Property Rights***	***Total credits: 02***
Teaching Scheme		***Evaluation Scheme***
Self-study		***CA : 50 Marks***
Theory : -Hrs/week		***Mid sem: -Marks***
Tutorial: -Hr/week		***End-Semester : 50 Marks***

Course Objectives	1. To make students aware of Project Management and intellectual property rights.
Course Outcomes	At the end of the course the student will be able to: 1. Enumerate and demonstrate fundamental terms such as copy-rights ,Patents Trademarks etc., 2. Interpret and follow Laws of copy-rights, Patents, Trademarks and various IP registration Processes to register own project research. 3. Exhibit the enhance capability to do economic analysis of IP rights, technology and innovation related policy issues and firms' commercial strategies. 4. Develop awareness at all levels (research and innovation) of society to develop patentable technologies. 5. Apply trade mark law, copy right law, patent law and also carry out intellectual property audits.
Course Contents: Students have to complete the course on line on NPTEL or SWAYAM portal	

Course Code : 20PEE302P	***PROJECT PHASE I***	***Total credits: 14***
Teaching Scheme		***Evaluation Scheme***
		CA : 50 Marks
Theory : -Hrs/week		***Mid sem: -Marks***
Tutorial: -Hr/week		***End-Semester : 50 Marks***

Course Objectives	2. To apply engineering knowledge to solve problem industry or society.
Course Outcomes	At the end of the course the student will be able to: 6. Identify suitable area of work and conduct detailed literature survey . 7. Formulate the problem statement . 8. Define aim and objectives of with probable solution methodology.
Pre-requisites	***All Electrical Engineering courses***
Course Type	***Project***
Course Contents The candidate who has presented will now formulate an appropriate problem statement for topic selected and define the aim and objectives along with then probable methodologies useful for the solution for the problem statement at the end of semester he/ she will make a comprehensive project Phase-I report in detail and make the presentations along with the future work towards fulfillment of the Project Phase-I.	

Course Code : 20PEE401P	***Project Stage II***	*Total credits: 28*
Teaching Scheme		*Evaluation Scheme*
		CA : 100 Marks
Theory : -Hrs/week		*Mid sem: -Marks*
Tutorial: -Hr/week		*End-Semester : 100 Marks*

SEMESTER IV

Course Objectives	3. To design the system develop the system and analyze its performance
Course Outcomes	At the end of the course the student will be able to: 9. Design and test the developed system. 10. Analyze the performance of the system. 11. Write the technical report. 12. Publish research paper Based on the total work carried.
Pre-requisites	***Project-Stage I***
Course Type	***Project***

Course Contents.

Based on the total work carried out in semester III and satisfactory performance, a candidate will be allowed to prepare the Project report for the final submission and evaluation.