Program Structure for
M.E. Electrical Engineering (Power Electronics and Drives)
Mumbai University
(With Effect from 2012-2013)

Semester I

Subject Code	Subject Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
PEDC101	Applied Engineering Mathematics*	04	--	--	04	--	--	04
PEDC102	Power Electronic Devices and Converters	04	--	--	04	--	--	04
PEDC103	Electrical Machine Analysis and Control	04	--	--	04	--	--	04
PEDE101X	Elective I	04	--	--	04	--	--	04
PEDE102X	Elective II	04	--	--	04	--	--	04
PEDL101	Power Electronics Simulations Lab	--	02	--	--	01	--	01
PEDL102	Power Electronics Hardware Lab	--	02	--	--	01	--	01
Total		**Total**	**04**	**--**	**20**	**02**	**--**	**22**

Subject Code	Subject Name	Examination Scheme							
		Theory					Term Work	Pract. /oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Durati-on (in Hrs)			
		Test1	Test 2	Avg.					
PEDC101	Applied Engineering Mathematics*	20	20	20	80	03	--	--	100
PEDC102	Power Electronic Devices and Converters	20	20	20	80	03	--	--	100
PEDC103	Electrical Machine Analysis and Control	20	20	20	80	03	--	--	100
PEDE101X	Elective I	20	20	20	80	03	--	--	100
PEDE102X	Elective II	20	20	20	80	03	--	--	100
PEDL101	Power Electronics Simulations Lab	--	--	--	--	--	25	25	50
PEDL102	Power Electronics Hardware Lab	--	--	--	--	--	25	25	50
Total		**Total**	**100**	**100**	**400**	**--**	**50**	**50**	**600**

*** Common for M.E. Electrical Engineering in Power System Engineering and Power Electronics and Drives**

Semester II

Subject Code	Subject Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
PEDC201	Modern Power Electronic Converters	04	--	--	04	--	--	04
PEDC202	Electrical Power Quality**	04	--	--	04	--	--	04
PEDC203	Advanced Machine Drives	04	--	--	04	--	--	04
PEDE203X	Elective III	04	--	--	04	--	--	04
PEDE204X	Elective IV	04	--	--	04	--	--	04
PEDL201	Applied Power Electronics Lab	--	02	--	--	01	--	01
PEDL202	DSP Applications Lab	--	02	--	--	01	--	01
Total		**Total**	**04**	**--**	**20**	**02**	**--**	**22**

Subject Code	Subject Name	Examination Scheme							
		Theory					Term Work	Pract. /oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test1	Test 2	Avg.					
PEDC201	Modern Power Electronic Converters	20	20	20	80	03	--	--	100
PEDC202	Electrical Power Quality**	20	20	20	80	03	--	--	100
PEDC203	Advanced Machine Drives	20	20	20	80	03	--	--	100
PEDE203X	Elective III	20	20	20	80	03	--	--	100
PEDE204X	Elective IV	20	20	20	80	03	--	--	100
PEDL201	Applied Power Electronics Lab	--	--	--	--	--	25	25	50
PEDL202	DSP Applications Lab	--	--	--	--	--	25	25	50
Total		**Total**	**100**	**100**	**400**	--	**50**	**50**	**600**

** **Common for M.E. Electrical Engineering in Power System Engineering and Power Electronics & Drives**

Semester III

Subject Code	Subject Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
PEDS301	Seminar	--	06	--	--	03	--	03
PEDD301	Dissertation I	--	24	--	--	12	--	12
Total		--	30	--	--	15	--	15

Subject Code	Subject Name	Examination Scheme						
		Theory				Term Work	Pract. / Oral	Total
		Internal Assessment			End Sem. Exam.			
		Test1	Test 2	Avg.				
PEDS301	Seminar	--	--	--	--	50	50	100
PEDD301	Dissertation I	--	--	--	--	100	--	100
Total		--	--	--	--	**150**	**50**	**200**

Semester IV

Subject Code	Subject Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
PEDD401	DissertationII	--	30	--	--	15	--	15
Total		--	30	--	--	15	--	15

Subject Code	Subject Name	Examination Scheme						
		Theory				Term Work	Pract. / Oral	Total
		Internal Assessment			End Sem.Exam			
		Test1	Test 2	Avg.				
PEDD401	DissertationII	--	--	--	--	100	100	200
Total		--	--	--	--	**100**	**100**	**200**

Note:

- In case of Seminar, 01 Hour / week / student should be considered for the calculation of load of a teacher
- In case of Dissertation I, 02 Hour / week / student should be considered for the calculation of load of a teacher
- In case of Dissertation II, 02 Hour / week / student should be considered for the calculation of load of a teacher
- **End Semester Examination:** In all six question to be set, each of 20 marks, out of these any four questions from different units of the subjects.

Subject Code	Elective I	Subject Code	Elective II
PEDE1011	Application of Power Electronics in Power System #	PEDE1021	Artificial Intelligence & its Application in Power System #
PEDE1012	Computational Electromagnetics	PEDE1022	Non-Conventional Energy Sources and Systems #
PEDE1013	Modern Control System #	PEDE1023	Dynamic Analysis of Synchronous Machine
PEDE1014	Advanced Protection System	PEDE1024	Distributed Generation and Microgrid #

 # Common for M. E. Electrical Engineering in Power System Engineering and Power Electronics & Drives

Subject Code	Elective III	Subject Code	Elective IV
PEDE2031	DSP and its Application in Power System ##	PEDE2041	Power Electronics Interfaces for Renewable Energy Systems
PEDE2032	Smart Grid ##	PEDE2042	Extra High Voltage Transmission ##
PEDE2033	Energy Management and Auditing ##	PEDE2043	EMI and EMC in Power Electronic Systems
PEDE2034	Special Machine Modeling and Control	PEDE2044	Entrepreneurship Development ##

Common for M. E. Electrical Engineering in Power System Engineering and Power Electronics & Drives

Subject Code	Subject Name	Credits
PEDC101	**Applied Engineering Mathematics**	**04**

Module	Contents	Hours
1	Vector space, subspace of vector space , span, linear independence, basis, dimension, linear functions and transformations, kernel(or null) and image (or range)subspaces, change of basis and similarity, invariant subspaces .	10
2	Matrices, norms, sensitivity, and condition number.	4
3	Solution of linear systems: LU and Cholesky factorizations. Effect of round off errors.	10
4	Linear least-squares problems: Normal equations, orthogonal transformations, QR factorization, singular value decomposition (SVD), conditioning.	14
5	Eigenvalues: reduction to canonical form, inverse iteration, QR algorithm, computing the SVD. Large sparse linear systems. Introduction to iterative methods.	10

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Books Recommended:

Text Books:

1. Demmel, Applied Numerical Linear Algebra, SIAM. Ist edition.
2. Golub& Van Loan, Matrix Computation, John Hopkins University Press.
3. Strang, Applied Linear Algebra, Wellesly Cambridge Press.
4. Watkins, Fundamentals of Matrix Computations, Wiley series of Tech.

Reference Books:

1. Trefethen and Bau, .Numerical Linear Algebra,

Subject Code	Subject Name	Credits
PEDC102	**Power Electronic Devices and Converters**	**04**

Module	Contents	Hours
1	**Power semiconductor Switches** Review of Power Devices: SCR, BJT, MOSFET, IGBT, GTO, Safe operating Limits, Selection of devices for various applications. Switching losses, Isolated and non-isolated Gate drives, Protection circuits: Snubber circuits, temperature control and heat-sinks.	08
2	**Phase controlled Converters** Single phase and three phase thyristor fed half controlled, fully controlled and Dual converters with inductive and motor load, effect of source inductance, twelve pulse converters	12
3	**DC to DC converters** Analysis of various conduction modes of Buck, Boost, Buck-Boost, Cuk and introduction to SEPIC converters, design and selection of inductor and capacitor	14
4	**Power Supply Applications** Overview of switching power supplies, fly back, forward , push-pull and full bridge converters, transformer core selection, current and voltage mode control, power supply protection, designing to meet power supply protection, Selection of converters for various applications	14

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Books Recommended:

Text Books:

1. N.Mohan, T.M.Undeland, W.P Robbins, "Power Electronics, Converters, Applications & Design," Wiley IndiaPvt.Ltd.
2. R W Erickson and D Maksimovic, "Fundamental of Power Electronics" Springer, 2nd Edition
3. M.H.Rashid, "*Hand book of Power Electronics"* , Academic Press,2001
4. Joseph Vithayathil "Power Electronics", Tata McGraw Hill
5. P.C.Sen "Power Electronics"

Reference Books/Journals

1. P. T. Krein, "Elements of Power Electronics", Oxford University Press
2. *IEEE Transactions on Power Electronics*
3. *IEEE Transactions Industrial Electronics*

4. *IECON ,APEC Proceedings etc*

Subject Code	Subject Name	Credits
PEDC103	**Electrical Machine Analysis and Control**	**04**

Module	Contents	Hours
1	**Basic Principle for Electrical Machine Analysis:** Introduction, Magnetically coupled circuit, Electromechanical energy conversion, Machine winding and air gap MMF, Winding inductance and Voltage equation	10
2	**Direct Current Machines:** Elementary DC machine, Voltage and Torque equations, Basic types of DC machines, Dynamic characteristics of permanent magnet and shun DC motors, Time domain block diagram and state equation, Solution of dynamic characteristics	05
3	**Reference Frame Theory:**Introduction, Equations of transformations, stationary circuit variables transformed to arbitrary reference frame, Commonly used reference frame, Transformation between reference frames, Transformation of a balanced set, Balanced steady state phasor relationship, Balanced steady state voltage equations.	09
4	**Symmetrical Induction Machine:** Introduction, Voltage equations in machine variables, Torque equations in machine variables, Voltage equations in arbitrary reference frame variables, Torque equations in arbitrary reference frame variables, Commonly used reference frames, Analysis of steady state operations, Free acceleration characteristics, Reduced order machine equation	12
5	**Synchronous machines:** Introduction voltage equations and Torque equations, Park's Equations	06
6	**Control of Induction Motors:** Concept of space vector, Introduction to field oriented control and direct torque control of induction motor	06

Assessment:

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End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Books Recommended:

Text Books:

1. "Analysis of Electric Machinery" P.C. Krause, McGraw Hill, New York
2. "Modern Power Electronics and A.C. Drive", B. K. Bose, , PHI
3. "Electric Motor Drives, Modeling, Analysis and Control" , R.Krishnan, PHI
4. "Generalized Theory of Electrical Machines", Dr. P.S.Bimbhra, Khanna Publishers

Reference Books:

1. "Control of Electrical Drives" W. Leonhard. Springer Verlag,

2. "Fundamentals of Electrical Drives", G. K. Dubey, Narosa Publishing House.

Subject Code	Subject Name	Credits
PEDE1011	**Application of Power Electronics in Power System**	**04**

Module	Contents	Hours
1	**Introduction**- Steady state and dynamic problems in AC systems- Transmission interconnections- Flow of power in an AC system- Loading capability- Power flow and dynamic stability considerations of a transmission interconnection- Relative importance of controllable parameters- FACTS Controllers- Basic types of FACTS controllers- Brief description and definitions- Benefits from FACTS technology- HVDC or FACTS	10
2	**Static shunt compensators and Static series compensation**- Objectives of shunt compensation- Methods of controllable Var generation- - Objectives of series compensation- Variable impedance type series compensation(only TCSC) , Switching converter type series compensation(only SSSC)	10
3	**Static voltage and phase angle regulators**- Objectives of voltage and phase angle regulators- TCVR and TCPAR, Switching converter based voltage and phase angle regulators	10
4	**Load compensation using DSTATCOM**- Compensating single phase loads- Ideal three phase shunt compensator structure-Series compensation of power distribution system- Rectifier supported DVR- DC Capacitor supported DVR- Fundamental Frequency series compensator characteristic	10
5	**Unified Power Quality Conditioner**- UPQC configuration-Right shunt UPQC characteristic- Left shunt UPQC characteristic	08

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End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Books Recommended:

Text Books:

1. Narain G. Hingorani and Laszlo Gyugyi, "Understanding FACTS Concepts and Technology of Flexible AC Transmission Systems," IEEE Press.
2. Arindam Ghosh and Gerard Ledwich, " Power Quality Enhancement Using Custom Power Devices," Kluwer Academic Publishers
3. Roger C. Dugan, Mark F. McGranaghan and H.WayneBeaty "Electrical Power System Quality" , Mc Graw Hill
4. J. Arrillaga, N.R.Watson and S.Chen " Power System Quality Assessment," John Wiley & Sons

5. Yong Hua Song "Flexible AC transmission system" Institution of Electrical Engineers, London

Reference Book/ Journals*:*

1. Jos Arrillaga and Neville R Watson "Power System Harmonics" Wiley Publications
2. G.T.Heydt , "Electric Power Quality," Stars in a Circle Publications
3. IEEE Transaction on Power Systems
4. IEEE Transaction on Power Delivery
5. IEEE Transaction on Power Electronics

Subject Code	Subject Name	Credits
PEDE1012	**Computational Electromagnetics**	**04**

Module	Contents	Hours
1	**Introduction to electromagnetic fields:** review of vector analysis, electric and magnetic potentials, boundary conditions, Maxwell's equations, diffusion equation, Poynting vector, wave equation	10
2	**Finite Difference Method (FDM):** Finite Difference schemes, treatment of irregular boundaries, accuracy and stability of FD solutions, Finite-Difference Time-Domain (FDTD) method	12
3	**Finite Element Method (FEM):** overview of FEM, Variational and Galerkin Methods, shape functions, lower and higher order elements, vectorelements, 2D and 3D finite elements, efficient finite element computations	12
4	**Method of Moments (MOM):** integral formulation, Green's functions and numerical integration, other integral methods: boundary element method, charge simulation method	08
5	**Applications:** low frequency and high frequency electrical devices, static / time-harmonic / transient problems in transformers, rotating machines, waveguides, antennas	06

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Books Recommended:

Text Books:

1. M. V. K. Chari and S. J. Salon"Numerical methods in electromagnetism", Academic Press, 2000.
2. M. N. O. Sadiku, "Numerical techniques in electromagnetics", CRC Press, 1992.

Reference Books:

1. N. Ida, , Chapman and Hall "Numerical Modeling For Electromagnetic Non-Destructive Evaluation", 1995.
2. S. R. H. Hoole, "Computer Aided Analysis And Design Of Electromagnetic Devices", Elsevier Science Publishing Co., 1989.
3. J. Jin, "The Finite Element Method in Electromagnetics", 2nd Ed., John Wiley and Sons, 2002.
4. P. P. Silvester & R. L. Ferrari ," Finite Elements For Electrical Engineers", 3rd ed., Cambridge University Press, 1996.

Subject Code	Subject Name	Credits
PEDE1013	**Modern Control System**	**04**

Module	Contents	Hours
1	State Space Representation, Solution of State Equation, State Transition Matrix, Canonical Forms - Controllable Canonical Form, Observable Canonical Form, Jordan Canonical Form.	08
2	Controllability and Observability, Canonical Realizations, Duality, Decomposition of Uncontrollable and Unobservable realizations, Popov test. Effect of state feedback on controllability and observability, Design of State Feedback Control through Pole placement. Full order observer and reduced order observer.	10
3	Introduction to nonlinear systems, Types of nonlinearities, describing functions, describing function analysis of nonlinear control systems. Introduction to phase-plane analysis, Method of Isoclines for Constructing Trajectories, singular points, phase-plane analysis of nonlinear control systems.	10
4	Stability in the sense of Lyapunov, Lyapunov's stability and Lypanov's instability theorems. Direct method of Lypanov for the Linear and Nonlinear continuous time autonomous systems.	08
5	Calculus of Variations: problems of Lagrange,. Mayer and Bolza. Euler-Language equation and transversality conditions, Lagrange multipliers. Pontryagin's maximum principle; theory; application to minimum time, energy and control effort problems, and terminal control problem.	12

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Books Recommended:

Text Books:

1. "Modern Control System Theory " by M. Gopal, New Age International Publishers, 2nd edition, 1996
2. D.E.Kirk, "Optimal Control Theory", Prentice-Hall. 1970.
3. M. Vidyasagar, "Nonlinear Systems Analysis". 2nd Edition.Prentice Hall, 1993.

Reference Books:

1. “Modern Control Engineering “, by K. Ogata, Prentice Hall of India, 3rd edition, 1998
2. “Control Systems Engineering”, by I.J. Nagarath and M.Gopal, New Age International (P)
3. “Digital Control and State Variable Methods “ by M. Gopal, Tata McGraw-Hill Companies, 1997.
4. “Systems and Control” by Stainslaw H. Zak , Oxford Press, 2003.

Subject Code	Subject Name	Credits
PEDE1014	**Advanced Protection System**	**04**

Module	Contents	Hours
1	**Classification Of Static Relays:** Basic construction of static relays, Classification of protective schemes, Comparison of Static relays with electromagnetic relays, Amplitude comparator, Phase comparator, Principle of Duality.	06
2	**Amplitude And Phase Comparators (2-Input):** Rectifier bridge circulating and opposed Voltage type- Averaging -phase splitting type -Sampling type of amplitude Comparison. Block spike type-Phase splitting type- Transistor integrating type-Rectifier bridge type- Vector product type Phase comparison.	08
3	**Static Over Current Relays:** Instantaneous- Definite time – Inverse time- Directional- IDMT- Very inverse Time-Extremely inverse time over current relays. Time current characteristics of Over current relays-applications	10
4	**Distance Protection:** Impedance Relay: operating principle-relay Characteristic-Protective Schemes-Static Impedance Relay-Static reactance relay- static MHO relay-effect of arc resistance, effect of power surges, effect of line length and source impedance on performance of distance relays-Quadrilateral relay – Elliptical relay.-selection of distance relays	06
5	**Pilot Relaying Schemes:** Wire pilot protection: circulating current scheme- balanced voltage scheme-translay scheme-half wave comparison scheme- Carrier current protection: phase comparison type-carrier aided distance protection-operational comparison of transfer trip and bloking schemes-optical fibre channels	06
6	**AC Machines And Bus Zone Protection:** Protection of Alternators: stator protection-rotor protection-over voltage protection-over speed protection-Transformer protection: earth faults in transformers-percentage differential protection-protection against magnetic inrush current-generator and transformer unit protection-Bus zone protection: differential current protection-high impedance relay scheme-frame leakage protection	06
7	**Microprocessor Based Protective Relays:** Introduction-over current relays-Impedance relay-Directional relay-Reactance relay.	06

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Books Recommended:

Text Books:

1. Anderson PM, “Power system protection,” McGraw-hill, 1999.

Reference Books:

1. Badriram&Vishwakarma, “Power system protection and SWG,” Mcgraw Hill

2. MadhavaRao TS, “ Power system protection with static relays and Microprocessor application,” McGraw hill

3. Singh LP, “Digital protection”

4. Mason CR, “The art and science of protective relaying,” John Wiley & sons

5. Chapman & Hall, “Electrical Power System Protection”

6. J.Lewis Blackburn & T.J. Domin, “Protective Relaying Principles & Applications”

Subject Code	Subject Name	Credits
PEDE1021	**Artificial Intelligence & its Application in Power System**	**04**

Module	Contents	Hours
1	**Fuzzy Logic:** Introduction to Neuro, Fuzzy and soft Computing, Fuzzy Sets, Basic Definition and Terminology, Set theoretic Operations, Member Function Formulation and parameterization, Fuzzy Rules and Fuzzy Reasoning, Extension principle and Fuzzy Relations, Fuzzy If-Then Rules, Fuzzy Reasoning, Fuzzy Inference Systems, Mamdani Fuzzy Models, Sugeno Fuzzy Models.	11
2	**Neural Networks:** Introduction, Supervised Learning Neural Networks, Perceptrons, Adaline, Back propagation Multilayer perceptrons, Radial Basis Function Networks, Unsupervised Learning and Other Neural Networks, Competitive Learning Networks, Kohonen Self Organizing Networks, Learning Vector Quantization, Hebbian Learning.	11
3	**Neuro Fuzzy Modelling:** Adaptive Neuro-Fuzzy Inference Systems, Architecture, Hybrid Learning Algorithm, learning Methods.	08
4	**Evolutionary computing:** Genetic algorithm: Basic concept , encoding , fitness function, Reproduction, Basic genetic programming concepts, differences between GA and Traditional optimization methods, Applications, Variants of GA. Simulated Annealing, Particle Swarm optimization	10
5	**Applications:** Fuzzy logic based controller for Electric Drive, ANN-based Speed Estimation, Flux &Torque Estimation in Induction Motor Drives Application of ANN and Fuzzy logic in Power System – Reliability, load forecasting, Load Dispatch.	08

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Books Recommended:

Text Books:

1. Sivandudam and Deepapublisher,"Principles of soft computing" John mikey India.
2. J.S.R.Jang, C.T.Sun and E.Mizutani, "Neuro -Fuzzy and Soft Computing", PHI.
3. B.Yegnanarayana, "Artificial Neural Network",PHI
4. JacekM.Zurada, "Introduction to Artificial Neural Systems", Jaico Publishing House
5. Simon haykin, "Neural Network" , Macmillan Publication,1994
6. H.J.Zimmermann, "Fuzzy set Theory & its Applications", Allied Publishers Ltd.
7. D. Prianleav, "Fuzzy control", Narosa Publication.
8. Davis E.Goldberg,"Genetic Algorithms: Search, Optimization and Machine Learning" Addison,Wesley.

Reference Books:

1 Shaykins- Neural Networks: A comprehensive foundation
2 S.Rajasekharan and G.A.V.Pai,"Neural Networks, Fuzzy Logic and Genetic Algorithms", PHI, 2003
3. R.Eberhart, P.simpson and R.Dobbins," Computational Intelligence, PC Tools", AP Professional, Boston 1996.
4. M.H.Rashid, " Power Electronics Handbook", Academic Press 2nd Ed.

Subject Code	Subject Name	Credits
PEDE1022	**Non-Conventional Energy Sources and Systems**	**04**

Module	Contents	Hours
1	**Introduction**-Worlds Production and reserves of commercial energy sources, India's Production and reserves, energy alternatives The Solar Option, The Nuclear Option, Tar sands and Oil Shale, Tidal Energy, Geothermal Energy	04
2	**Solar Radiation**- The sun and earth, solar radiation- availability, measurement and estimation, The sun and earth movement, angle of Sunrays, on solar collector radiation, Estimation solar radiation empirically	04
3	**Solar Thermal applications**-solar thermal conversion devices and storage applications, Liquid flat plate collector, Solar air heater, concentric collectors, thermal energy storage, solar pond,	04
4	**Solar Photovoltaic**- Introduction to solar cells , solar cell characteristics, losses in solar cells , Model of a solar cell , emerging solar cell Technologies Solar PV modules from solar cells , Mismatch in module , hot spots in the module , Bypass diode , Design and structure of PV modules , PV module power output , I-V and power curve of module BOS of PV system**,** Batteries, Battery charge controllers ,DC to DC Converters , DC to AC Converters for AC loads ,Supporting structures for mounting the PV panels , MPPT, Different algorithms for MPPT, Types of PV systems	12
5	**PV system Design and Applications**- Design methodology of standalone PV system , Wire sizing in PV system, Precise sizing of PV System, Economic analysis of PV system	06
6	**Wind Energy**- History of wind energy, Wind machine types, classification, and parameters, , general concepts of airfoils and aerodynamics, Analysis of wind flow, measurement of wind speed, Power in wind, performance calculations of wind turbine	06
7	**Fuel Cell**- Introduction to fuel cell, principle of operation of fuel cell, stack configuration, Fuel cell Performance, Polymer electrolyte fuel cell, alkaline fuel cell, phosphoric acid fuel cell, molten carbonate fuel cell, solid oxide fuel cells, components of fuel cell, thermodynamics of fuel cell, Fuel cell systems, applications	06
8	**Other Sources**- Biomass- Biomass as a source of energy, introduction, energy plantation, methods of obtaining energy from biomass, photosynthesis, biomass gasification, factors affecting bio-digestion, classification of biogas plants, thermal gasification of biomass, pyrolysis Tide- Basic principle of tide power, components of tidal power plant, operation methods of utilization of tidal energy, Ocean Thermal Electric Conversion (OTEC)- Introduction, open cycle OTEC systems, closed cycle OTEC systems	06

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Books Recommended:

Text Books:

1. S. P Sukhatme "Solar Energy- Principle of Thermal collector and storage," Third edition, TMH publication
2. Chetan Singh Solanki , "Solar Photo Voltaics" ,PHI learning Pvt Ltd., New Delhi,2009
3. "Fuel Cell Handbook", EG&G Technical Services, Inc,USDept of Energy, seventh edition,2004
4. Rashid M.H, " Power Electronics Handbook" ,Academic Press,California,USA,2001
5. J. A. Duffie and W. A. Beckman "Solar Engineering of Thermal Processes," second edition, John Wiley, New York, 1991
6. G D Rai "Non-Conventional Energy Sources," Khanna Publications

Reference Books:

1. "Fuel Cell System", Leo J.M.J. Blomen and michael N. Mugerwa, New York, Plenum Press, 1993.
2. Green M.A " Solar Cells": Operating Principles, technology and System Applications, Prentice Hall Inc, Englewood Cliffs N.J, U.S.A, 1982
3. J.F. Manwell, J.G. McGowan " Wind Energy Explained, theory design and applications," Wiley publication
4. James Larminie, Andrew Dicles "Fuel Cell Systems Explained," Wiley publication
5. "Principles of Solar Engineering", D. Y. Goswami, F. Kreith and J. F. Kreider, Taylor and Francis, Philadelphia, 2000
6. "Biomass Regenerable Energy", D. D. Hall and R. P. Grover, John Wiley, New York, 1987.
7. "Renewable Energy Resources", J. Twidell and T. Weir, E & F N Spon Ltd, London, 1986.

Subject Code	Subject Name	Credits
PEDE1023	**Dynamic Analysis of Synchronous Machine**	**04**

Module	Contents	Hours
1	**Basic Concepts,** Review of Classical Methods	04
2	**Modeling of Synchronous Machine,** Synchronous Machine, Park's Transformation, Analysis of Steady State Performance, Per Unit Quantities, Equivalent Circuits of synchronous Machine, Determination of parameters of equivalent circuits, Transient Analysis of synchronous machine	12
3	**Modeling of** Excitation system, Transmission lines, Static Var Compensator, Loads	08
4	**Dynamics of synchronous Generator connected to infinite bus,** System model and simulation, Inclusion of SVC Model	08
5	**Analysis of Single Machine System,** Small Signal Analysis with Block Diagram Representation, Characteristic equation and application of Routh Hurwitz Criterion, Synchronizing and damping torques analysis Small Signal Model, Nonlinear oscillation	10
6	**Analysis of Multi-machine System Model,** Detail models, Inclusion of load and SVC Dynamics, Model Analysis of large power system	06

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Books Recommended:

Text books/Reference books

1. "Power system Dynamics Stability and Control" K R Padiyar B S Publication
2. "Power system Dynamics Stability" Peter W . Sauer and M A Pai Pearson Education Asia
3. "Power system Dynamics Stability and Control" P Kundur
4. "Power system Control and Stability" P M Anderson and A.A Fouad

Subject Code	Subject Name	Credits
PEDE1024	**Distributed Generation and Microgrid**	**04**

Module	Contents	Hours
1	**Introduction:** Conventional power generation: advantages and disadvantages, Energy crises, Non-conventional energy (NCE) resources: review of Solar PV, Wind Energy systems, Fuel Cells, micro-turbines, biomass, and tidal sources. Impact of grid integration of NCE sources on existing power system: reliability, stability and power quality issues, Energy storage elements: Batteries, ultra-capacitors, flywheels. Captive power plants	12
2	**Distributed Generations (DG):** Concept of distributed generations, topologies, selection of sources, regulatory standards/ framework: IEEE 1547, DG installation classes, requirements for grid interconnection, limits on operational parameters,: voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues, security issues in DG implementations	14
3	**Microgrids:** Concept of microgrid, review of sources of microgrids, typical structure and configuration of a microgrid, AC and DC microgrids, Power Electronics interfaces in DC and AC microgrids, communication infrastructure, modes of operation and control of microgrid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques, Power quality issues in microgrids, regulatory standards, Microgrid economics, Introduction to smart microgrids	22

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Books Recommended:

Text Books:

1. "Voltage Source Converters in Power Systems: Modeling, Control and Applications", Amirnaser Yezdani, and Reza Iravani, IEEE John Wiley Publications
2. "Power Switching Converters: Medium and High Power", DorinNeacsu, CRC Press, Taylor &Francis, 2006
3. "Solar Photo Voltaics", Chetan Singh Solanki, PHI learning Pvt. Ltd., New Delhi,2009
4. "Fuel Cell Handbook", EG&G Technical Services, Inc, US Dept of Energy, seventh edition, 2004
5. M.H.Rashid, "Power Electronics Handbook", Academic Press 2nd Ed.

References books /websites

1. "IEEE-1547-2003: IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems" IEEE standards 2003
2. "IEEE 1547-2: IEEE Guide for Monitoring, Information Exchange, and Distributed Resources Interconnected Electric Power Systems" IEEE
3. "IEEE 1547-4 : IEEE Guide for Design Operation & Integration of Distributed Resources Island System with Electric Power System, IEEE standards
4. Consortium for Electric Reliability Technology Solutions (CERTS) white paper on Integration of Distributed Energy Resources: The CERTS MicroGrid Concept
5. "Fuel Cell System", Leo J.M.J. Blomen and michael N. Mugerwa, New York, Plenum Press, 1993.
6. "Wind Energy Explained, theory design and applications," J.F. Manwell, J.G. McGowan Wiley publication
7. "Biomass Regenerable Energy", D. D. Hall and R. P. Grover, John Wiley, New York, 1987.
8. "Renewable Energy Resources" John Twidell and Tony Weir, Tyalor and Francis Publications, Second edition

Subject Code	Subject Name	Credits
PEDL101	**Power Electronics Simulation Lab**	**01**

Objectives: Analysis of basic power electronic circuits (open loop) using various simulation softwares (eg. MATLAB, PSPICE, Proteus Software, Sci lab, C-PROGRAM, SEQUEL). Minimum two softwares to be used. Minimum eight simulations to be carried out.

Module	Detailed content	Lab. Sessions
1	**Using C program write two program such as** • Generate a sinusoidal waveform • FFT analysis for any signal	02
2	**Simulation** • Three phase controlled rectifier including source inductance • Non isolated DC-DC converter • Isolated DC-DC converter • Bidirectional Covereter • Synchronous Rectifier • Static VAR compensator • Modelling and control of DC Motor • Modelling and control of induction motor	10

End Semester Examination: Practical/Oral examination is to be conducted by pair of internal and external examiners

Subject Code	Subject Name	Credits
PEDL102	**Power Electronics Hardware Lab**	**01**

Objectives: Hardware Implementation of basic power electronic circuit (open loop) mentioned in Power Electronics Simulation Lab. Minimum two hardware implementation and its detailed analysis must be carried out. And characterization of any one of Renewable Sources. Maximum two students in a group.

Module	Detailed content	Lab. Sessions
1	**Design and Hardware Implementation(any two)** • Static var compensator • DC-DC Converter • DC-AC Converter • DC motor drive • AC motor drive	10
2	**Characteristics of Renewable Sources (Any One)** • I-V and P-V Characteristics of solar panel at different Atmospheric Conditions • I-V and P-V Characteristics of fuel cell • Characterization of Wind Energy Systems output	02

End Semester Examination: Practical/Oral examination is to be conducted by pair of internal and external examiners

Subject Code	Subject Name	Credits
PEDC201	**Modern Power Electronic Converters**	**04**

Module	Contents	Hours
1	**Switch-Mode Inverters:** Basic concepts of VSI, single phase half bridge, full bridge and three phase bridge inverters, PWM modulation strategies, Sinusoidal PWM, Space vector modulation, Selective Harmonic Elimination method, Other inverter switching schemes, blanking time, Current source inverters	16
2	**Multi Level Inverter:** Need for multilevel inverters, Three level and four level inverter operation and analysis. N level inverter topology Applications of multilevel inverters and control. Four leg inverters	08
3	**Resonant Converters** Basic resonant circuit concepts, Load resonant converters, series and parallel loaded, Resonant switch converters - ZVS,ZCS, comparison of resonant converters	08
4	**Converter dynamics** Review of classical methods of modeling, State space model of various dc to dc converters, State space averaging techniques.	12
5	**Applications of converters** Residential applications, Industrial Applications, Electric utility applications, Renewable energy technology applications	04

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Books Recommended:

Text Books:

1. N.Mohan, T.M.Undeland, W.P Robbins, "Power Electronics, Converters, Applications & Design," Wiley IndiaPvt.Ltd.
2. R W Erickson and D Maksimovic, "Fundamental of Power Electronics" Springer, 2nd Edition
3. M.H.Rashid, "*Hand book of Power Electronics"* , Academic Press,2001
4. Joseph Vithayathil "Power Electronics", Tata McGraw Hill

Reference Books/Journals:

1. P. T. Krein, "Elements of Power Electronics", Oxford University Press
2. P.C.Sen, "Power Electronics"
3. *IEEE Transactions on Power Electronics*
4. *IEEE Transactions Industrial Electronics*
5. *IECON ,APEC Proceedings etc*

Subject Code	Subject Name	Credits
PEDC202	**Electrical Power Quality**	**04**

Module	Contents	Hours
1	**Introduction**-power quality-voltage quality-overview of power quality phenomena- voltage and current variations, events, overview of voltage magnitude events	08
2	**Power quality measures and standards**-THD-TIF-DIN-C-message weights-flicker factor-transient phenomena-occurrence of power quality problems-power acceptability curves-IEEE guides, standards and recommended practices, Related problems.	10
3	**Harmonics**-Harmonic distortion- voltage vs current distortion in power system-individual and total harmonic distortion-RMS value of a harmonic waveform, Related problems	06
4	**Harmonic introducing devices and its effects**-SMPS-Three phase power converters-arcing devices- saturable devices-harmonic distortion of fluorescent lamps- power quality problems created by drives and its impact on machines-effect of power system harmonics on power system equipment and loads.	06
5	**Power factor compensation-** power factor compensation in linear circuits-Basic relationship**,** complex power, apparent power and power factor, power factor compensation in linear sinusoidal circuits **,** Non-linear circuits with sinusoidal supply-Basic relationship**,** complex power, apparent power and power factor, power factor compensation in linear sinusoidal circuits- Problems related to power factor calculation is included.	10
6	**Harmonic compensation**- Passive Compensation- Passive Filtering-harmonic filter design- active filters-shunt active filters- Generation of reference current using instantaneous PQ theory- Other methods for generation of reference current(two more)- methods of implementation- Basic schematic and working of series active filter-unified power quality conditioner.	08

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Books Recommended:

Text Books:

1. Roger C. Dugan, Mark F. McGranaghan and H.WayneBeaty, "Electrical Power System Quality," MC Graw Hill
2. G.T.Heydt , "Electric Power Quality," Stars in a Circle Publications
3. J. Arrillaga, N.R.Watson and S.Chen, " Power System Quality Assessment," John Wiley & Sons

4. W. Shepherd and P. Zand, " Energy flow and power factor in non-sinusoidal circuits" Cambridge university press
5. IEEE-519: 1992, IEEE Recommended Practices and Requirements for Harmonic Control in Electric Power Systems

Reference Book/Journals:

1. Jos Arrillaga, B.C.Smith, Neville R Watson and A.R.Wood, "Power System Harmonics Analysis" Wiley 1997
2. Math H.J.Bollen, " Understanding Power Quality Problems,Voltage Sag and Interruptions " Wiley-IEEE Press
3. IEEE Transactions on Power Systems
4. IEEE Transactions on Power Delivery
5. IEEE Transaction on Power Electronics

Subject Code	Subject Name	Credits
PEDC203	**Advanced Machine Drives**	**04**

Module	Contents	Hours
1	**Scalar Control of Induction Motor:** Variable frequency operation of three phase symmetrical induction machine: scalar control methods(voltage fed inverter control and current fed inverter control),Efficiency Optimization control by flux program	12
2	**Vector Control of Induction Machine:** Introduction, direct or feedback vector control, flux vector estimation, indirect or feed forward vector control, vector control of line side PWM rectifier, stator flux oriented vector control, vector control of current fed inverter drive, sensorless vector control, Direct Torque and Flux Control, Adaptive control	20
3	**Wound Rotor Induction Motor Control:** static rotor resistance control, static Scherbius drive, Improvement in power factor, introduction to variable speed constant frequency (VSCF) generation	08
4	**Sinusoidal SPM Machine Drives:** V/Hz control, self control model, Vector control	08

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Books Recommended:

Text Books:

1. "Modern Power Electronics and A.C. Drive", B. K. Bose, , PHI.
2. "Electric Motor Drives: Modeling, Analysis and Control" ,R.Krishnan,.PHI
3. "Control of Electrical drives", W. Leonhard, , Springer-Verlag,.

Reference Books:

1. "Power Semiconductor Controlled Drives" ,G. K. Dubey, Prentice-Hall International.
2. "Fundamentals of Electrical Drives", G. K. Dubey, Narosa Publishing House.
3. "Analysis of Electric Machinery" P.C. Krause, McGraw Hill, New York

Subject Code	Subject Name	Credits
PEDE2031	**DSP and its Applications in Power System**	**04**

Module	Contents	Hours
1	**Introduction** Review of microprocessor, microcontroller and digital signal processors architecture, Fixed and floating-point processors Number formats and operations: Fixed point 16 bit numbers representations of signed integers and fraction, Floating Point Numbers. Review of commonly used DSP processors in power electronics applications, introductions to TMS320F2812 and TMS320C2000 processors	06
2	**DSP Architecture, peripherals and programming** Introduction to Digital control using DSP, Overview of TMS320C2000 Digital signal controller family – Features, Architecture, Interrupt and Reset, Memory map - On-chip memories: Flash, RAM, and Boot ROM – External memory Interface. Clock system- Digital I/O -CPU Timers – Analog to Digital Converter (ADC), Pulse Width Modulator (PWM), High Resolution PWM, Capture Module, Quadrature Encoder Pulse Module. Controller Area Network, Serial Communication Interface, Serial Peripheral Interface, I^2C and Multi-channel Buffered Serial port. Programming: assembler, linker processes, code structure, Code composer studio	16
3	**Mathematical tools for Real Time DSP implementation** Review of numerical integration: Euler's implicit and explicit method, Heun's Method, Trapezoidal Method. Implementation of low pass filter. Review of reference frame transformation theory. Design of controllers for closed loop applications in power electronics: PI, Type II and Type III controllers	08
4	**DSP Applications in Power Electronics** Speed control of Induction motor, BLDC motor, Digital control of DC/DC converter, LED Lighting.	06
5	**DSP Applications in Power Systems** Issues of harmonics and unbalanced currents in power systems, Implementation of Active filters in DSP under balanced and unbalanced condition, harmonic oscillator and 3ϕ phase lock loop, Static VAR Compensator, Hardware in Loop simulations. Design of a DSP controlled Solar PV based Converter/Inverter system:	12

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination

Books Recommended:

Text Books:

1. "Power Electronics, Converters, Applications & Design",N.Mohan, T.M.Undeland, W.P Robbins, Wiley India Pvt.Ltd.
2. "Modern Power Electronics and AC Drives", B. K Bose, Perason Education
3. Hamid Toliyat and Steven Campbell "DSP Based Electromechanical Motion Control" CRC Press
4. Sen M. Kuo and Woon-SengGan "Digital Signal Processors - Architectures, Implementations, and Applications" Prentice Hall

References books /websites

1. C2000 Teaching ROM CD
2. Code Composer Studio v4: http://processors.wiki.ti.com/index.php/Category:Code_Composer_Studio_v4

Subject Code	Subject Name	Credits
PEDE2032	**Smart Grid**	**04**

Module	Detailed Contents	Hours
1	**Introduction to Smart Grid:** Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Functions of Smart Grid, Opportunities & Barriers of Smart Grid, Difference between conventional & smart grid, Concept of Resilient & Self Healing Grid, Present development & International policies in Smart Grid. Case study of Smart Grid. CDM opportunities in Smart Grid	08
2	**Smart Grid Technologies: Part 1:** Introduction to Smart Meters, Real Time Prizing, Smart Appliances, Automatic Meter Reading(AMR), Outage Management System(OMS), Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation, Phase Shifting Transformers	08
3	**Smart Grid Technologies: Part 2:** Smart Substations, Substation Automation, Feeder Automation. Geographic Information System(GIS), Intelligent Electronic Devices(IED) & their application for monitoring & protection, Smart storage like Battery, SMES, Pumped Hydro, Compressed Air Energy Storage, Wide Area Measurement System(WAMS), Phase Measurement Unit(PMU).	10
4	**Power Quality Management in Smart Grid:** Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.	10
5	**Information and Communication Technology for Smart Grid:** Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighborhood Area Network (NAN), Wide Area Network (WAN). Bluetooth, ZigBee, GPS, Wi-Fi, Wi-Max based communication, Wireless Mesh Network, Basics of CLOUD Computing & Cyber Security for Smart Grid. Broadband over Power line (BPL). IP based protocols	12

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination

Books Recommended:

Text Books:

1. Ali Keyhani, Mohammad N. Marwali, Min Dai "Integration of Green and Renewable Energy in Electric Power Systems", Wiley
2. Clark W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response", CRC Press
3. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", Wiley
4. Jean Claude Sabonnadière, NouredineHadjsaïd, "Smart Grids", Wiley Blackwell

References/Journal Papers:

1. Smart Grid Technologies: Communication Technologies and Standards Vehbi C. Güngör, DilanSahin, TaskinKocak, SalihErgüt, Concettina Buccella, Carlo Cecati, and Gerhard P. Hancke, IEEE TRANSACTIONS ON INDUSTRIAL INFORMATICS, VOL. 7, NO. 4, NOVEMBER 2011
2. Smart Grid – The New and Improved Power Grid: A Survey" , Xi Fang, Satyajayant Misra, Guoliang Xue, *Fellow*, *IEEE*, andDejun Yang,
3. *IEEE transaction on SmartGrids*

Subject Code	Subject Name	Credits
PEDE2033	**Energy Management and Auditing**	**04**

Module	Contents	Hours
1	**Energy Scenario:** Present Energy Scenario, Energy Pricing, Energy Sector Reforms, Energy Security, Energy Conservation and its Importance, Energy Conservation Act-2001 and its Features. Basics of Energy and its various forms, Material and Energy balance	04
2	**Energy Management & Audit:** Definition, Energy audit- need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution, Energy audit Instruments energy management, Roles and responsibilities of energy Manager and Accountability, Financial analysis techniques, Financing options, Energy performance contracts and role of ESCOs. Defining monitoring & targeting, Elements of monitoring& targeting, Data and information-analysis, Techniques - energy consumption, Production, Cumulative sum of differences.	06
3	**Energy Efficiency in Electrical system:** Electricity billing, Electrical load management and maximum demand Control, Maximum demand controllers; Power factor improvement, Automatic power factor controllers, efficient operation of transformers, Energy efficient transformers; Induction motors efficiency, motor retrofitting, energy efficient motors, Soft starters, Variable speed drives; Performance evaluation of fans and pumps, Flow control strategies and energy conservation opportunities in fans and pumps, Energy efficiency measures in lighting system, Electronic ballast, Occupancy sensors, Energy efficient lighting controls Factors affecting selection of DG system, Energy performance assessment of diesel conservation avenues	14
4	**Energy Conservation in Thermal Systems** Types of boilers, Combustion in boilers, Performances evaluation, Feed water treatment, Blow down, Energy conservation opportunities in boiler, Properties of steam, Assessment of steam distribution losses, Steam leakages, Steam trapping, Condensate and flash steam recovery system, Identifying opportunities for energy savings. Classification, General fuel economy measures in furnaces, Excess air, Heat Distribution, Temperature control, Draft control, Waste heat recovery. Insulation-types and application, Economic thickness of insulation, Heat savings and application criteria. Introduction, Mechanism of fluidized bed combustion, Advantages, Types of FBC boilers, Operational features, Retrofitting FBC system to conventional boilers, Saving potential.	14

	HVAC system: Coefficient of performance, Capacity, Factors affecting Refrigeration and Air conditioning system performance and savings opportunities. Classification and Advantages of Waste Heat Recovery system, analysis of Waste heat recovery for Energy saving opportunities	
5	**Energy Performance Assessment:** On site Performance evaluation techniques, Case studies based on: Motors and variable speed drive, Fans and pumps, HVAC system calculations; Lighting System: Installed Load Efficacy Ratio(ILER) method Financial Analysis: simple payback period, NPV, IRR,	10

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination

Books Recommended:

Text Books:

1.Handbook of Electrical Installation Practice. , By Geofry Stokes, Blackwell Science
2.Designing with light: Lighting Handbook., By Anil Valia, Lighting System
3.Energy Management Handbook., By W.C. Turner, JohnWiley and Sons
4.Handbook on Energy Audits and Management., edited by Amit Kumar Tyagi, Tata Energy Research Institute (TERI).

Reference Book/Websites:

1.Energy Management Principles., By C.B.Smith, Pergamon Press
2.Energy Conservation Guidebook., Dale R. Patrick, Stephen Fardo, Ray E. Richardson,Fairmont Press
3.Handbook of Energy Audits., By Albert Thumann,William J. Younger, Terry Niehus, CRC Press

Websites:

1. *www.energymanagertraining.com*
2. *www.bee-india.nic.in*

Subject Code	Subject Name	Credits
PEDE2034	**Special Machine Modeling and Control**	**04**

Module	Contents	Hours
1	**Control of Permanent Magnet Machines:** Introduction, Design Considerations, Modeling of PMSM, Modeling of Brushless DC Motor ,Operation, Speed Control Using PWM Inverter, Vector Control of PMSM, Operating Modes, Constant Torque Angle Control, Unity Power Factor Control, Maximum Torque Per Ampere Control ,Flux Weakening Control, Direct Torque Control of PM Motor, Sensorless Control of PM Motor , Position Information from Measurement of Voltages and Currents, Position Information from Measurement of Inductance Variation, Sensorless Control of BLDC Motor.	20
2	**Switched Reluctance Motor Drives (SRM):** Introduction, Construction , Linear SR Motors , Basic Principle of Operation ,Design of SR Machine, Selection of Poles ,Stator and Rotor Pole Angle Selection, Converters for SR Machine, Analytical Model of SR Machine, Control of SR Motor Drive, General Purpose SRM Drive with Speed/Position Sensor ,Design of Current Controllers, Torque Control, Direct Torque Control of SRM Drive, Sensorless Control of SRM Drives. Synchronous reluctance motor control, Stepping motor control	20
3	**Control of Multiphase AC Motor Drives:** Introduction, Modeling of a Five Phase Induction Motor, Machine Model in Arbitrary Reference Frame, Vector Control of Five-Phase Induction Motor , Five-Phase Inverters, SVPWM Five-Phase Voltage Source Inverter ,Five-Phase Permanent Magnet Motor Drives	08

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination

Books Recommended:

Text Books:

1. "High Performance AC Drives: Modelling Analysis and Control",Mukhtar Ahmad, Springer
2. "Modern Power Electronics and A.C. Drive", B. K. Bose, PHI.
3. "Electric Motor Drives: Modeling, Analysis and Control" ,R.Krishnan,.PHI
4. "Advanced Electrical Drives: Analysis, Modeling, Control" Rik De Dongaretal, Springer

Reference Books:

1. "Control of Electrical drives", W. Leonhard, , Springer-Verlag,.
2. "Fundamentals of Electrical Drives", G. K. Dubey, Narosa Publishing House.
3. "Analysis of Electric Machinery" P.C. Krause, McGraw Hill, New York

Subject Code	Subject Name	Credits
PEDE2041	**Power Electronics Interfaces for Renewable Energy Systems**	**04**

Module	Contents	Hours
1	**Introduction renewable sources and systems :** Review of renewable energy sources, operating principles and characteristics of: Solar PV, Wind Energy Systems (WES), Fuel cells, Economics and statistics related to renewable energy, Distributed generation system: basic concepts, design and development of stand alone systems and grid connected systems, Power quality and protection issues, review of regulatory standards related to various aspects of renewable energy systems.	10
2	**Design of Power Electronics Interfaces for Solar PV** Solar PV technologies, MPPT (maximum power point tracking) Design of DC-DC converters for MPPT, MPPT algorithms, Implementation of MPPT control through DSP controllers. Topologies for grid connected and standalone applications: single phase and three phase systems, Single stage and multistage, isolated and non- isolated. Design of multi stage solar PV grid connected and standalone systems. Low and high power Applications, Control implementation through DSP, Protection system design	18
3	**Design of Power Electronics Interfaces for WES** Topologies of WES, design considerations for WES with rectifier / inverter system, Power Converters for Doubly Fed Induction Generators (DFIG) in Wind Turbines, Matrix converter topology for grid connected system.	10
4	**Design of Power Electronics Interfaces for Fuel Cells** Types of fuel cells, Proton Exchange Membrane (PEM) fuel cell: features and operational characteristics, Design of DC-DC converters for PEM fuel cell, MPPT in Fuel Cell, Design considerations for multi-stage converter / inverter system for grid connected operations, Design considerations for protection system.	10

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination

Books Recommended:

Text Books:

1. "Power Electronics, Converters, Applications & Design",N.Mohan, T.M.Undeland, W.P Robbins, Wiley India Pvt.Ltd.
2. "Modern Power Electronics and AC Drives", B. K Bose, Pearson Education
3. "Voltage Source Converters in Power Systems: Modeling, Control and Applications", Amirnaser Yezdani, and Reza Iravani, IEEE John Wiley Publications
4. "Power Switching Converters: Medium and High Power" ,DorinNeacsu, CRC press, Taylor &Francis, 2006

5. M.H.Rashid, "Power Electronics Hand book" , Academic Press,2001
6."Solar Photo Voltaics", Chetan Singh Solanki , PHI learning Pvt Ltd., New Delhi,2009

References books /websites

1. "DSP Based Electromechanical Motion Control", Hamid Toliyat and Steven Campbell, CRC Press
2. "Digital Signal Processors - Architectures, Implementations, and Applications", Sen M. Kuoand Woon-SengGan Prentice Hall
3. "Fuel Cell System", Leo J.M.J. Blomen and michael N. Mugerwa, New York, Plenum Press, 1993.
4. "Wind Energy Explained, theory design and applications," J.F. Manwell, J.G. McGowan Wiley publication
5. "Fuel Cell Systems Explained," James Larminie, Andrew Dicles, Wiley publication
6. "Principles of Solar Engineering", D. Y. Goswami, F. Kreith and J. F. Kreider, Taylor and Francis, Philadelphia, 2000
7. "Biomass Regenerable Energy", D. D. Hall and R. P. Grover, John Wiley, New York, 1987.

Subject Code	Subject Name	Credits
PEDE2042	**Extra High Voltage Transmission**	**04**

Module	Contents	Hours
1	INTRODUCTION Standard transmission voltage-different configurations of EHV and UHV lines-average values of line parameters-power handling capacity and line loss-costs of transmission lines and equipment-mechanical considerations in line performance.	9
2	CALCULATION OF LINE PARAMETERS Calculation of resistance, inductance and capacitance for multi-conductor lines-calculation of sequence inductances and capacitances-line parameters for different modes of propagation-resistance and inductance of ground return, numerical example involving a typical 400/220 kv line using line constant program	10
3	VOLTAGE GRADIENT OF CONDUCTORS Charge-potential relations for multi-conductor lines-surface voltage gradient on conductors-gradient factors and their use-distribution of voltage gradient on sub conductors of bundle-voltage gradients on conductors in the presence of ground wires on towers.	10
4	CORONA EFFECTS Power losses and audible: I2R loss and corona loss-audible noise generation and characteristics-limits for audible noise-Day-night equipment noise level-radio interference: corona pulse generation and properties-limits for radio interference fields.	9
5	ELECROSTATIC FIELD OF EHV LINES Effect of EHV line on heavy vehicles-calculation of electrostatics filed of AC lines-effects of high field on humans, animals, and plants-measurements of electrostatics fields-electrostatic induction in unexercised circuit of a D/c line- induced voltages in insulated ground wires-electromagnetic interference.	10

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination

Books Recommended:

Text Books:

1. Rakosh Das Begamudre *"Extra high voltage AC Transmission Enginnering",* Second New Age International Pvt. Ltd.1990.
2. Power Engineer's Handbook, Revised and Enlarged 6th Edition, TNEB Engineer's Association.

Subject Code	Subject Name	Credits
PEDE2043	**EMI and EMC in Power Electronics Systems**	**04**

Module	Contents	Hours
1	**Fundamentals of EMI and EMC** Electromagnetic Fields: static, quasi-static and high frequency fields, Sources of EMI and their classifications, propagation and crosstalk, effect of EMI on devices and systems, general interference control techniques, Human exposure limits to EM fields, Need for EMC compliance, EMC standards, Measurement and testing, general EMC design principles for power electronic systems	16
2	**EMI/ EMC Design for PCBs** Fundamentals, sources, grounding, return circuit design, controlling EMI sources, decoupling power / ground planes, EMC filter Design, PCB layouts , Shielding in enclosures, EMI/EMC design for printed circuit boards for power electronics applications	16
3	**Testing for EMC Compliance** Instrumentations; Time and frequency domain analyzers, Test facilities, open area sites, chambers , TEM and GTEM cells, Probes, Antennas, and support equipments, Testing of conducted and radiated emissions, Immunity testing and In Situ testing, troubleshooting and solutions for minimization of emissions, Software and hardware tools for EMC	16

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination

Books Recommended

Text Books:

1. "Power Electronics, Converters, Applications & Design",N.Mohan, T.M.Undeland, W.P Robbins, Wiley India Pvt.Ltd.
2. "PCB Design for Real World EMI Control", Bruce R. Archambeault , Kluwer Academic Publishers Group, 2002
3. "Electromagnetic Compatibility in Power Systems", Francesco Larrarulo, Elsevier, 2002
4. "EMI Troubleshooting Techniques" Michel Mardiguin, McGrawHill, 2000
5. "Principles and Techniques of Electromagnetic Compatibility", Christos Christopoulous, CRC Press, Second edition
6. "Electromagnetic Modelling of Power Electronic Converters", J.A Ferreira, Kluwer Academic Publishers Group
7. "Testing for EMC Compliance: Approaches and Techniques", Mark Montrose, E.M Nakauchi, IEEE Press, Wiley Interscience, 2004
8. "EMI Filter Design" Richard Lee Ozenbaugh., CRC Press
9. "Engineering Electromagnetic Compatibility", V. Prasad Kodali, IEEE Press, second edition

Subject Code	Subject Name	Credits
PEDE2044	**Entrepreneurship Development**	**04**

Module	Contents	Hours
1	**Entrepreneurship concept** – Entrepreneurship as a Career – Entrepreneurial Personality - Characteristics of Successful, Entrepreneur – Knowledge and Skills of Entrepreneur.	10
2	**Business Environment** - Role of Family and Society - Entrepreneurship Development Training and Other Support Organisational Services - Central and State Government Industrial Policies and Regulations - International Business.	10
3	**Sources of Product for Business** - Prefeasibility Study - Criteria for Selection of Product - Ownership - Capital - Budgeting Project Profile Preparation - Matching Entrepreneur with the Project - Feasibility Report Preparation and Evaluation Criteria.	06
4	**Finance and Human Resource** Mobilization Operations Planning - Market and Channel Selection - Growth Strategies - Product Launching.	12
5	**Monitoring and Evaluation of Business** - Preventing Sickness and Rehabilitation of Business Units- Effective Management of small Business	10

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination

Books Recommended:

Text Books:

1. Hisrich, Entrepreneurship, Tata McGraw Hill, New Delhi, 2001.
2. S.S.Khanka, Entrepreneurial Development, S.Chand and Company Limited, New Delhi, 2001.

Reference Books:

1. Mathew Manimala, Entrepreneurship Theory at the Crossroads, Paradigms & Praxis, Biztrantra ,2nd Edition ,2005
2. Prasama Chandra, Projects – Planning, Analysis, Selection, Implementation and Reviews, Tata McGraw-Hill, 1996.
3. P.C.Jain (ed.), Handbook for New Entrepreneurs, EDII, Oxford University Press, New Delhi, 1999.
4. Staff College for Technical Education, Manila and Centre for Research and Industrial Staff Performance, Bhopal, Entrepreneurship Development, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 1998.
5. P. Saravanavel, Entrepreneurial Development, Ess Pee kay Publishing House,

Subject Code	Subject Name	Credits
PEDL201	**Applied Power Electronics Lab**	**01**

Objectives: Design and implementation of closed loop control of various power electronic topology.

Module	Detailed content	Lab. Sessions
1	**Design and Simulation (Any two)** • Power factor improvement in rectifiers • Control of power sharing between two DC-DC converters • Multilevel Inverter • Grid synchronization of renewable energy based converter/inverter system and control of active power • Variable frequency or Vector control of induction motor • Development of virtual instrumentation software interface for power electronics hardware through suitable VI software	08
2	**Experimentation** • Variable frequency or Vector control of induction motor • PLC Controlled Drives	04

End Semester Examination: Practical/Oral examination is to be conducted by pair of internal and external examiners

Subject Code	Subject Name	Credits
PEDL202	**DSP Applications Lab**	**01**

Objectives: Study basics of DSP programming and various control strategies implementation through DSP in power electronic based system

Module	Detailed content	Lab. Sessions
1	**Write program in DSP/ Microprocessor (any four)** • Generation of sine wave • Sense a non-sinusoidal voltage/current and find out harmonic content in it • Generation of Sine-PWM signals • Implementation of dq reference transformations • Implementation of Harmonic Oscillator • PLL implementation	06
2	**DSP Controlled Applications (An y Three)** • Closed loop control of DC-DC converter • Power factor correction in converters • LED lamp intensity control • Solar PV based converter / inverter system • Speed control of BLDC / PMSM motor • Communication System protocol implementation	06

End Semester Examination: Practical/Oral examination is to be conducted by pair of internal and external examiners

Subject Code	Subject Name	Credits
PEDS301	**Seminar**	**03**

Guidelines for Seminar

- Seminar should be based on thrust areas in Electrical Engineering
- Students should do literature survey and identify the topic of seminar and finalize in consultation with Guide/Supervisor. Students should use multiple literature and understand the topic and compile the report in standard format and present in front of Panel of Examiners appointed by the Head of the Department/Institute of respective Programme.
- Seminar should be assessed based on following points
  - Quality of Literature survey and Novelty in the topic
  - Relevance to the specialization
  - Understanding of the topic
  - Quality of Written and Oral Presentation

Subject Code	Subject Name	Credits
PEDD301 / PEDD401	**Dissertation (I and II)**	**12 + 15**

Guidelines for Dissertation

- Students should do literature survey and identify the problem for Dissertation and finalize in consultation with Guide/Supervisor. Students should use multiple literature and understand the problem. Students should attempt solution to the problem by analytical/simulation/experimental methods. The solution to be validated with proper justification and compile the report in standard format.

Guidelines for Assessment of Dissertation I

- Dissertation I should be assessed based on following points
  - Quality of Literature survey and Novelty in the problem
  - Clarity of Problem definition and Feasibility of problem solution
  - Relevance to the specialization
  - Clarity of objective and scope
- Dissertation I should be assessed through a presentation by a panel of Internal examiners appointed by the Head of the Department/Institute of respective Programme.

Guidelines for Assessment of Dissertation II

- Dissertation II should be assessed based on following points
  - Quality of Literature survey and Novelty in the problem
  - Clarity of Problem definition and Feasibility of problem solution
  - Relevance to the specialization or current Research / Industrial trends
  - Clarity of objective and scope
  - Quality of work attempted
  - Validation of results
  - Quality of Written and Oral Presentation
- Dissertation II should be assessed through a presentation jointly by Internal and External Examiners appointed by the University of Mumbai

Students should publish at least one paper based on the work in reputed International / National Conference (desirably in Refereed Journal)