

DEPARTMENT OF ELECTRICAL ENGINEERING
College of Technology and Engineering, Udaipur-313001
POST GRADUATE PROGRAMME, 2011-12

Details of P.G. Programme Courses offered for the award of PhD degree in Electrical Engineering

S. No.	Title	Course No.	Cr. Hr.	Semester			
				I	II	III	IV-VI
Core Courses							
<i>Ph.D. Degree: Total 6 credits (3 credits in each semester) one course in first semester and one course in second semester to be evaluated externally.</i>							
1	Advanced Power Converters	EPE 611	3 (3+0)	3	-	-	-
3	High Voltage dc Transmission system	EPE 612	3 (3+0)	3	-	-	-
3	Modeling & Analysis of Electrical machine	EPE 621	3 (3+0)	-	3	-	-
4	Utility Applications of Power Electronics	EPE 622	3 (3+0)	-	3	-	-
Major Courses							
<i>Ph.D. Degree: Total 12 credits (6 credits in each semester) two courses in first and second semester each.</i>							
1	Analysis & control of Electrical drive systems	EPE 613	3 (3+0)	3	-	-	-
2	Power system reliability	EPE 614	3 (3+0)	3	-	-	-
3	Flexible AC transmission system	EPE 615	3 (3+0)	3	-	-	-
4	Neural Networks	EPE 623	3 (3+0)	-	3	-	-
5	Intelligent Techniques in Electric Drives	EPE 624	3 (3+0)	-	3	-	-
6	Power electronics application for renewable energy	EPE 625	3 (3+0)	-	3	-	-
Minor/Supporting Courses							
<i>Ph.D. Degree: Total 9 credits, two courses in first semester (6 credits) and one course in second semesters (3 credits).</i>							
1	Analysis of Power Electronic Converters	EPE 616	3 (3+0)	3	-	-	-
2	Power system optimization	EPE 617	3 (3+0)	3	-	-	-
3	Fuzzy logic theory	EPE 618	3 (3+0)	3	-	-	-
4	Selected topics in Power Electronics	EPE 626	3 (3+0)	-	3	-	-
5	Power system Stability	EPE 627	3 (3+0)	-	3	-	-
Others							
	Compulsory Courses	-	Non Credit	3	-	-	-
	Seminar	EPE 631	2 (0+2)	-	-	2	-
	Thesis	EPE 632	45 (0+45)	-	-	-	45
	Total Credit Hours Ph.D. (74)			15	12	2	45

**Ph.D. Degree: The minimum duration of thesis will be 4 semesters.

A Ph.D. student must take a minimum of two 600 series core courses but may also take 500 series courses if not studied during Masters Programme as per ICAR recommendations.

Course Summary

Ph.D. Programme

Courses	No. of Courses Semester							Total	Credit Hours
	I	II	III	IV	V	VI			
Core	1	1	-	-	-	-	2	6	
Major	2	2	-	-	-	-	4	12	
Supporting/Minor	2	1	-	-	-	-	3	9	
Seminar	-	-	1	-	-	-	1	2	
Thesis	-	-	1	-	-	-	1	45	
Compulsory Courses	1	-	-	-	-	-	1	Non Credit	
Total	6	4	2	-	-	-	12	74	

PhD PROGRAM in Electrical Engineering 2011-12

SYLLABUS

EPE 611 Advanced Power Converters

	L	T	P
Credit	3	0	0
Hours	3	0	0

Control Methods for Power Converters: Control using State-Space Averaged Models, Sliding-Mode Control, Fuzzy Logic Control, Multilevel Converters,

Basic concepts of Switched Mode power converters, DC-DC converters Characteristics, constituent elements, operating principles. Steady state analysis, stress and sizing of elements, control methods, duty ratio, current programmed, frequency programmed and sliding mode control, Dynamic analysis and frequency domain models.

Resonant and Soft-Switching Converters: Classification, Basic resonant circuit concepts, Quasi-Resonant Converters, Load resonant converters, Resonant switch converters, Zero voltage switching. Design of feed back compensators, unity power factor rectifiers, resistor emulation principle and applications to rectifiers

Working and operating principle of High frequency ac link converters, matrix converter, space vector modulation

Text Books/References:

1. Switched Mode Power Conversion, Course Notes, CCE, IISc, 2004.
2. Issa Batarseh, 'Power Electronic Circuits', John Wiley, 2004.
3. Philip T Krein, 'Elements of Power Electronics', Oxford Press.

EPE 612 High Voltage dc Transmission system

	L	T	P
Credit	3	0	0
Hours	3	0	0

HVDC Transmission: Basic scheme and equipment of converter station, 12 – pulse converter, converter unit, converter operation, filters, reactive power source, ground return and ground electrode, Comparison between AC and DC transmissions, Application of HVDC transmission. Converter Circuits: Rectification and inversion, effect of reactance, six pulse and twelve pulse converter circuits.

DC Link Control: Principles of DC link control, Converter control characteristics, System control hierarchy, Firing angle control, Extinction angle control, starting, stopping and power flow reversal of DC link, Power control, Parallel operation of DC link with AC transmission line; Converter faults, commutation failure, valve blocking and bypassing; Protection against over currents, over voltages; DC circuit breaker; Reactive Power Control: Reactive power requirement in steady state, Sources of reactive power and reactive power control; Power modulation and power control of HVDC lines

Harmonic and Filters: Generation of harmonics, AC and DC side harmonics, characteristics and non-characteristics harmonics. Types of AC filters – single tuned and double tuned filters, high pass filter, DC Smoothing reactor and filters; Scheme of a HVDC converter station and components of HVDC transmission system.

Multi Terminal DC (MTDC) Systems: Types of MTDC systems, Comparison of series and parallel MTDC systems, Control and protection of MTDC systems, Application of MTDC systems.

EPE 621 Modeling & Analysis of Electrical machine

	L	T	P
Credit	3	0	0
Hours	3	0	0

Energy state functions. Modelling of electromechanical systems. Matrix methods and use of generalized circuit theory of machines. Different methods of transformation d.c. phase variable, instantaneous symmetrical component techniques. Reference frames. Development of basic performance equations and analysis of different rotating machine such as d.c. synchronous and induction machines. Dynamics and transients in electric machines. Switching transients and surges.

Transient and short circuit studies on alternators. Run-up reswitching and other transient in induction machines. Relevant computer techniques for machine analysis. Modelling of special electrical machines.

Text and Reference books:

1. Computer Aided analysis of machine elements – R. V. Dukkipati, PHI
2. Electrical Machine Design – M G Say, TMH
3. Electric Motor Drive : Modeling, Analysis and Control by Krishnan, PHI

EPE 622 Utility Applications of Power Electronics

	L	T	P
Credit	3	0	0
Hours	3	0	0

Static shunt compensators: Objectives, Methods of controllable VAR generation, Static VAR compensators SVC, and STATCOM, Comparison between SVC, TATCOM and static VAR systems

Static series compensators: Objectives, Variable impedance type, Switching converter type, System control and comparison, Combined compensators: PFC, IPFC, Generalized and multi functional FACTS controllers

Active power filters: Types, shunt active filters, Series active filters

Power Converters in Static Excitation Systems, HVDC Power Transmission: Converters, technology, Voltage sourced converters, Single phase converters, Three phase converters, Transformer connections, 24 and 48

pulse operation, Three level converter and converter ratings, Self and line commutated CSC

Utility interface: Current harmonics, and p.f., standards, Single phase interface, Three phase interface, EMI.

Text and Reference books:

1. Padiyar.K.R., HVDC TRANSMISSION SYSTEMS, New Age International, 2006.
2. Mohan.N, Undeland.T.M., Robbins.W.P., POWER ELECTRONICS, John Wiley & Sons (Asia) Pte. Ltd, 3rd ed., 2003.
- 3.Rashid.M.H(Ed)., POWER ELECTRONICS HANDBOOK, Elsevier, 2001.
4. Padiyar.K.R., FACTS CONTROLLERS IN POWER TRANSMISSION AND DISTRIBUTION, New Age International, 2007.

EPE 613 Analysis & control of Electrical drive systems

	L	T	P
Credit	3	0	0
Hours	3	0	0

DYNAMICS OF ELECTRIC DRIVES: Mechanical system, fundamental torque equations, components of load torque's, nature and classification of load torques, speed-torque conventions and multi-quadrant operation, equivalent values of drive parameters, Dynamic conditions of a drive system, Energy loss in transient operations, steady state stability, load equalization, close loop configurations of drives.

DC DRIVES: Basics of DC machines, Speed torque curves, torque and power limitation in armature voltage and field control, Starting, Braking-Regenerative Braking, dynamic braking and plugging, Transient analysis of separately excited motor with armature and field control, Energy losses during transient operation, Speed Control-Controlled Rectifier fed DC drives, Dual-converter control of DC drive, Chopper Controlled DC drives

INDUCTION MOTOR DRIVES: Basics of Induction Machines, Starting, Braking-Regenerative braking, plugging and dynamic braking, Transient analysis, Calculation of energy losses, Speed Control-Stator voltage control, variable frequency control from voltage source, Voltage Source Inverter (VSI) Control, Variable frequency control from current source, Current Source Inverter (CSI) Control, Cyclo-converter Control, Static rotor resistance control, Slip Power Recovery- Stator Scherbius drive, Static Kramer drive.

SYNCHRONOUS MOTOR DRIVE: Control of Synchronous Motor-Separately Controlled and VSI fed Self-Controlled Synchronous Motor Drives. Dynamic and Regenerative Braking of Synchronous Motor with VSI, Control of Synchronous Motor Using Current Source Inverter (CSI), Speed control – variable frequency control, Cycloconverters control

Text and Reference books:

1. Power electronics and A C Drives – B K Bose, Pearson, India
2. Power electronics: circuits, drives and applications – H Rashid, Pearson, India
3. A C Drives – J M D Murphy, John Wiley student edition

EPE 614 POWER SYSTEM RELIABILITY

	L	T	P
Credit	3	0	0
Hours	3	0	0

Basic Reliability Concepts : Combinatorial reliability - series, parallel and series-parallel configuration: Multi-state models, Stand-by system models, Catastrophic failure models – Treatment of failure data. Reliability in terms of hazards rate and failure density. Different hazard methods. *System Reliability* – Series, parallel, series parallel system configuration. Approximation and bounds, meantime to failure, Stand-by operation. General approach to computation of system reliability, Computer methods of analysis. *Reliability Improvement* – Introduction, Proper design and simplicity, Component improvement, Redundancy, Stand by redundancy, Repairable Systems, Basic ideas of maintainability, Evaluation of reliability of physical systems.

Text and References Books:

1. Systems reliability – Jacob / Russel
2. Systems reliability – Chowdury / Nagpal

EPE 615 FLEXIBLE A.C TRANSMISSION SYSTEM

	L	T	P
Credit	2	0	1
Hours	2	0	2

The phenomenon of voltage collapse; the basic theory of line compensation. Static excitation system; static VAR compensators; static phase shifters; thyristor controlled series capacitors. Co-ordination of FACTS devices with HVDC links. the FACTS optimization problem transient and dynamic stability enhancement using FACTS components. Advanced FACTS devices- the STATCON and unified power flow controller.

Text and Reference Books:

1. FACTS – Guilder
2. FACTS – Bhatnagar / Soni

EPE 623 NEURAL NETWORKS

	L	T	P
Credit	2	0	1
Hours	2	0	2

Artificial neural systems :Preliminaries, fundamental concepts & models of artificialsystem, neural networks learning rules, Hebbian, perceptron, delta Widrow-Hoff learning rules. Single layer perceptron classification : Classification model, features & decision regions training & classification using discrete perception, algorithm & examples, single layer continuous perceptron networks for linear separable classification. Single layer feedback networks : basic concepts of dynamical systems mathematical modeling of discrete time & gradient type Hopfield networks, transient response of continuous time network solution optimization problems. Multilayer feedback work networks : Generalized delta learning rule, feedforward recall & error back propagation training, learning factors.Neural network in control system : Neuro-control approaches, training algorithm evaluation of training algorithms, through simulation, self tuning neuro-control scheme, self tuning PID neural controller, neuro-control scheme feed water bath temperature control system.

Text Books/References :

1. Introduction of artificial neural systems - J.M.ZURADA, Jaico publication House 1997
2. Neural networks: comprehensive foundation-S.IIAYKIN McMillian College Publishing company inc. 1994
3. Neuro control and its application - S.OMATU, M.KHALID, R.YUSOF. Spring Verlag London Ltd. 1996.
4. An introduction to fuzzy control - D.DRIANKOV, H. HELLENDORRN and M REINFRANK Narosa Publication House, 2nd reprint 1997.
5. Neural Network Design, - Hagan, Demuth Deak Thomson Learning

	L	T	P
Credit	3	0	0

EPE 624 Intelligent Techniques in Electric Drives

Mathematical of fuzzy control: fuzzy sets, fuzzy set theory, properties of fuzzy sets, Operations of fuzzy sets, fuzzy relations .Non linear fuzzy control: The control problem, FKBC as non linear transfer element PID & sliding mode type FKBC, some typical application of fuzzy based control systems. Adaptive Fuzzy control: Introduction, design & performance evaluation, performance monitor, main approaches to design. Stability of fuzzy control system: state space approach, stability and robustness indices, input-output stability. FKBC design parameters: Structure of FKBC fuzzification and defuzzification module, rule based choice of variable and contents of rules, derivation of rule data based, choice of membership function and scaling factors,

Artificial neural systems: Preliminaries, fundamental concepts & models of artificial system, neural networks learning rules, Hebbian, perceptron, delta Widrow-Hoff learning rules; Single layer perceptron classification: Classification model, features & decision regions training & classification using discrete perception, algorithm & examples, single layer continuous perceptron networks for linear separable classification; Multilayer feedback work networks: Generalized delta learning rule, feedforward recall & error back propagation training, learning factors. Single layer feedback networks : basic concepts of dynamical systems mathematical modeling of discrete time & gradient type Hopfield networks, transient response of continuous time network solution optimization problems.

Text Books/References:

1. Introduction of artificial neural systems - J.M.ZURADA, Jaico publication House 1997
2. Neural networks: comprehensive foundation - S.IIAYKIN McMillian College Publishing company inc. 1994
3. Neuro control and its application - S.OMATU, M.KHALID, R.YUSOF. Spring Verlag London Ltd. 1996.
4. An introduction to fuzzy control - D.DRIANKOV, H. HELLENDORRN and M REINFRANK Narosa Publication House, 2nd reprint 1997.
5. Neural Network Design, - Hagan, Demuth Deak Thomson Learning
6. Neuro-fuzzy and soft computing, PHI publication
7. Fuzzy logic : Intelligence control and Information, - John Yen Pearson publication.

EPE 625 Power electronics application for renewable energy

	L	T	P
Credit	3	0	0
Hours	3	0	0

Modern power electronics technology for the integration of renewable energy sources, various topologies of power electronics converters (PECs), grid interconnection requirements for wind farms, integration issues, operational issues, grid integration issues in India, challenges for grid integration, wind power integration standards, supergrid strategy, IEC standadrds for wind turbines, power electronics in wind power plants, power electronics converters (PEC) classifications, Applications of PEC in wind power plants, Modern PEC in wind power plants. Power electronics in PV system

Text Books/References:

1. Wind power plants and projects developments, Joshua Earnest and T Wizelius, PHI, New Delhi, 2011.
2. Handbook of renewable energy technology, World Scientific, Siongapore, 2011.

EPE 616 Analysis of Power Electronic Converters

	L	T	P
Credit	3	0	0
Hours	3	0	0

Phase Controlled Converters: Performance measures of single and three-phase converters with discontinuous load current for R, RL and RLE loads. Effect of source inductance for single and three phase converters
Chopper: Review of choppers configurations, Steady state analysis of type A Chopper-Minimum and Maximum Currents, Ripple and average load current. Commutation in Chopper Circuits
Inverters: Performance parameters, Principle of Operation, Single-phase bridge inverters, Three phase bridge Inverters: 180 and 120 degree of conduction, Current source inverters , voltage control of three phase inverters-Sinusoidal PWM, Third Harmonic PWM, 60 degree PWM and Space Vector Modulation. Harmonic reductions

AC Voltage Controllers: Principle of On-Off Control, Principle of Phase control, Single Phase Bi-directional Controllers with Resistive Loads, Single Phase Controllers with Inductive Loads, Three Phase full wave AC controllers, AC Voltage Controller with PWM Control.

Cyclo-converters: Single phase and three phase Cyclo-converters. Reduction in Output Harmonics, Matrix Converter

Text and Reference books:

- 1 Advanced Power electronics – Vinod Kumar, R. R. Joshi, R C Bansal, Agarwal and Sharma, Vardhan Publication and distributors, Jaipur, India
- 2 Power electronics – N. Mohan, John Wiley student edition, Singapore
- 3 Power electronics : circuits, drives and applications – H Rashid, , Pearson, India

EPE 617 Power System Optimization

	L	T	P
Credit	3	0	0
Hours	3	0	0

Economic load dispatch in thermal and hydro-thermal system; reactive power. optimization; optimal power flow. Linear programming and non-linear programming techniques to optimal power flow problems. Security constrained optimization. Unit commitment and maintenance scheduling, interchange evaluation, minimum emission dispatch.

Text and Reference books:

1. Optimisation techniques in power systems – Sawla / Hatteres, New age International, India
2. Optimisation-Theory and Applications, Wiley Eastern Ltd. - S. S. Rao
3. Optimisation Methods for Engineering Design, Addison Wesley - R. L. Fox

EPE 618 FUZZY LOGIC THEORY

	L	T	P
Credit	3	0	0
Hours	3	0	0

Introduction Scope of applications for power electronics and control. Problems faced with classical approach and solutions offered by fuzzy schemes. Uncertainty and imprecision, Statistics and Random processes, Uncertainty in information. *Classical Sets and Fuzzy sets : Classical Relations and Fuzzy Relations* : Cartesian product, Crisp relations, Fuzzy relations, Tolerance and equivalence relations, Fuzzy tolerance and equivalence relations, Value assignments. *Membership Functions* : Features of the membership function, Standard forms and boundaries, Fuzzification, Membership value assignments. *Fuzzy-to-Crisp Conversions*: Lambda-Cuts for Fuzzy sets, Lambda-Cuts for Fuzzy relations, Defuzzification methods. *Fuzzy Arithmetic, Numbers, Vectors and the Extension Principle*: Extension principle, Fuzzy numbers, Interval analysis in arithmetic, Approximate methods of extension, Fuzzy vectors. *Classical Logic and Fuzzy Logic* : Classical predicate logic, Fuzzy logic, Approximate reasoning, Fuzzy tautologies, contradictions, equivalence, and logical proofs, Other forms of the implication operation, Other forms of the composition operation. *Fuzzy Rule-Based Systems* : Natural language, Linguistic hedges, Rule-based systems, Graphical techniques of inference. *Fuzzy Nonlinear Simulation* : Fuzzy relationship equations, Partitioning, Nonlinear simulation using Fuzzy rule-based systems, Fuzzy associative memories (FAMs). *Fuzzy Decision Making* : Fuzzy synthetic evaluation, Fuzzy ordering, Preference and consensus, Multiobjective decision making, Fuzzy Bayesian decision method, Decision making under Fuzzy states and Fuzzy actions.

Text and Reference books:

1. Fuzzy-Neural Control : Principles, Algorithm and Applications By Nie & Linkens, PHI
2. Fuzzy Logic with Engineering Applications By Timothy Ross, TMH
3. Fuzzy Sets and Fuzzy Logic: Theory and Applications By Klir & Yuan, Pearson India

EPE 626 SELECTED TOPICS IN POWER ELECTRONICS

L	T	P
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Credit 3 0 0
Hours 3 0 0

Series resonant inverters, parallel resonant inverters, class E resonant converter, zero voltage switching resonant converter, zero current switching converter, Two quadrant ZVS converter and resonant d.c. link inverter. Review of scalar control, Direct and Indirect field oriented control, direct torque control. Recent trends in PWM techniques. Mathematical and graphical analysis of indirect space vector modulation. Modeling and control of BLDC, PMSM, SRM, IM, stepper motor drive. Introduction to Matrix converter, high frequency ac link converter

Text and Reference Books:

1. Advanced power electronics – Gilbert, John Wiley
2. Power electronics and A C Drives – B K Bose, Pearson, India
3. Power electronics : circuits, drives and applications – H Rashid, Pearson, India

EPE 627 POWER SYSTEM STABILITY

L T P
Credit 3 0 0
Hours 3 0 0

Synchronous Machines: Modelling of cylindrical rotor synchronous machine, flux linkage equations, voltage equations and equivalent circuit, real and reactive power control. Modelling of salient pole synchronous machine (Two – axis model), flux linkage equations, Park’s transformation, current and voltage equations.

Transient and subtransient effects, reactances and time constants of synchronous machines. Equivalent circuits, vector diagrams, power angle equations and characteristics under steady state and transient conditions.

Steady State and Dynamic Stabilities: Development of swing equation, linearisation of swing equation. Steady state stability of single machine connected to an infinite bus system and two machine systems. Coherent and non-coherent machines. Swing equation including damping effect. Introduction to dynamic stability of power system. Introduction to classical model of multi machine system.

Transient Stability: Equal area criterion and its application to transient stability studies under common disturbances including short circuits. Critical clearing angle and critical clearing time. Numerical solution of swing equation by step-by-step method.

Multi machine Transient Stability: Numerical methods for solution of differential equations: Modified Euler Method, Runge – Kutta fourth order method. Multi machine transient stability studies using modified Euler method and Runge – kutta fourth order method. (ii) Factors affecting steady state and transient stabilities. Methods of improving steady state, dynamic and transient stabilities, series capacitor compensation of lines, excitation control, power stabilizing signals, High speed circuit breaker, auto – reclosing circuits breaker, single pole and selective pole operation, by pass valving and Dynamic braking.

References:

- i) Power System Stability And Control, McGraw Hill, 1994, P. Kundur,
- ii) Power system Stability, K.R.Pediyar
- iii) Power system operation control., M.Pai

Compulsory Courses

EPE 631 Seminar

EPE 632Thesis