DEPARTMENT OF ELECTRICAL ENGINEERING

College of Technology and Engineering, Udaipur-313001

POST GRADUATE PROGRAMME, 2013-14

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 *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.*							
1	**Selected topics in power electronics**	EPE 611	3 (2+1)	3	-	-	-
3	Electricity energy marketing	EPE 612	3 (2+1)	3	-	-	-
3	**Selected Topics in Power System and control**	**EPE 621**	**3 (2+1)**	**-**	**3**	-	-
4	Utility Applications of Power Electronics	EPE 622	3 (2+1)	-	3	-	-
Major Courses *Ph.D. Degree: Total 12 credits (6 credits in each semester) two courses in first and second semester each.*							
1	**High Voltage dc Transmission system**	EPE 613	3 (3+0)	3	-	-	-
2	**Flexible AC transmission system**	EPE 614	3 (3+0)	3	-	-	-
3	ANN and Fuzzy Logic	EPE615	3 (3+0)	3	-	-	-
4	**Analysis & control of Electrical drive systems**	**EPE 623**	**3 (3+0)**	**-**	**3**	**-**	**-**
5	**Wind Energy conversion system**	**EPE 624**	**3 (3+0)**	**-**	**3**	**-**	**-**
Minor/Supporting Courses *Ph.D. Degree: Total 9 credits, two courses in first semester (6 credits) and one course in second semesters (3 credits).*							
1	**Analysis of Power Electronic Converters**	EPE 616	3 (3+0)	3	-	-	-
2	Modeling & Analysis of Electrical machine	EPE 617	3 (3+0)	3	-	-	-
3	**Power system optimization**	EPE 618	3 (3+0)	3	-	-	-
4	Power electronics application for renewable energy	EPE 625	3 (3+0)	-	3	-	-
5	**Power Quality in distributed system**	**EPE 626**	**3 (3+0)**	**-**	**3**	**-**	**-**
6	Power system reliability	EPE 627	3 (3+0)	-	3	-	-
Others							
	Compulsory Courses						
	Library & Information service	PGS501	NC	3	-	-	-
	Technical writing and communication skill	PGS502	NC	-	3	-	-
	Seminar	EPE 619	2 (0+2)	1	-	-	-
		EPE 628		-	1	-	-
	Preliminery Examinations (Oral and written)	EPE 632	Non Credit	-	-	Non Credit	-
	Thesis	EPE 633	45 (0+45)	-	-	-	45
	Total Credit Hours Ph.D. (74)			15	12	2	45

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							Credit Hours
	I	II	III	IV	V	VI	Total	
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	-	-	-	-	2	Non Credit
Total	6	5	2	-	-	-	13	74

PhD Program in Electrical Engineering 2013-14

SYLLABUS

EPE 611 SELECTED TOPICS IN POWER ELECTRONICS

	L	T	P
Credit	2	0	1
Hours	2	0	2

Controller Design: Review of frequency-domain analysis of linear time-invariant systems, concept of bode plot, phase and gain margins, bandwidth, controller specifications, proportional (P), proportional plus integral (PI), proportional plus integral plus integral controller (PID), selection of controller parameters.

Resonant Converters: Classification of Resonant converters-Basic resonant circuits- Series resonant circuit-parallel resonant circuits- Resonant switches. Concept of Zero voltage switching, principle of operation, analysis of M-type and L-type Buck or boost Converters. Concept of Zero current switching, principle of operation, analysis of M-type and L-type Buck or boost Converters, parallel resonant inverters, class E resonant converter, Two quadrant ZVS converter and resonant d.c. link inverter.

Multilevel Converters: Basic concept, classifications, working principle, applications

Review of Scalar Control, Direct and Indirect Field Oriented Control, Direct Torque Control.

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 612 Electricity energy marketing

	L	T	P
Credit	2	0	1
Hours	2	0	2

Overview of the Electric Power Industry: History of the Electric Power Industry, Deregulation Overview, Vertical Integration, Market Structure in the India.

Overview of Economic Theory: Supply & Demand, Consumer Surplus & Producer Surplus, Price Taking, Profit Maximization, Monopoly, Game Theory, Equilibrium Models(Reduce), Market Power (Hockey Stick Bidding, Deck Game, Measurements of market power), Auctions, Theory of Second Best (Transmission Expansion, Carbon Tax).

Optimization: Introduction to Linear Optimization, Linear Programming (Convex sets, Primal and Dual, Proof of Optimality, Duality Theory), Mixed Integer Linear Programming, heuristic optimization methods.

Dispatch Optimization Models: Material: Economic Dispatch, Direct Current Optimal Power Flow(DCOPF), Unit Commitment.

Pricing: Uniform Market Clearing Prices (MCP) vsPay as Bid, Locational Marginal Pricing (LMPs).

Objectives, Rents, Congestion: Dual of the DCOPF, Load payment, Congestion Rent, Generation Rent.

Financial Transmission Rights: Simultaneous Feasibility Test, Revenue inadequacy.

Reference Books:

1. Market Operations in Electric Power Systems: Forecasting, Scheduling, and Risk Management by M. Shahidehpour, Zuyi Li andHatimYamin, IEEE Computer Society Press (first published March 28th 2002).

EPE 613 High Voltage dc Transmission system

	L	T	P
Credit	3	0	0
Hours	3	0	0

Thyristor Valve: Thyristor device, Steady state and switching characteristics, light activated power thyristor, LED, fiber optics, valve firing, parallel and series connections of thyristors.
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 breakers. Reactive Power Control: Reactive power requirement in steady state, Sources of reactive power and reactive power control.
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.
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.

References / Suggested Text Books

1. K.R. Padiyar: HVDC Power Transmission System, 2nd Edition, New Age Intl. Pvt. Ltd., 2012.

EPE 614 FLEXIBLE A.C TRANSMISSION SYSTEM

	L	T	P
Credit	3	0	0
Hours	3	0	0

The phenomenon of voltage collapse; the basic theory of line compensation Problems of AC transmission systems, power flow in parallel paths and meshed system, factors limiting loading capability, stability consideration. Power flow control of an ac transmission line. Basic types of facts controllers. Advantages of FACTS technology
Voltage-Sourced Converters: Basic concept of voltage-sourced converters, single and three phase bridge converters. Introduction to power factor control. Transformer connections for 12- pulse, 24 pulse and 48 pulse operations.
Static Shunt Compensators: Midpoint and end point voltage regulation of transmission line, and stability improvement. Basic operating principle of Static Synchronous Compensators (STATCOM).Comparison between STATCOM and SVC.
Static Series Compensators: Concept of series capacitive compensation, voltage and transient stabilities, power oscillation and subsynehronous oscillation damping. Introduction to thyristor- switched series capacitor (TSSC), thyristor controlled series capacitor (TCSC), and static synchronous series compensator-operation, characteristics and applications.

Static Voltage and Phase Angle Regulators: Voltage and phase angle regulation. Power flow control and improvement of stability by phase angle regulator. Introduction to thyristor controlled voltage and phase angle regulators (TCVR and TCPAR).(ii) Introduction to thyristor controlled braking resistor and thyristor controlled voltage limiter.

UPFC: Unified Power Flow Controller (UPFC), basic operating principles, conventional transmission control capabilities. Comparison of UPFC to series compensators and phase angle regulator. Applications of UPFC.**IPFC:** Interline Power Flow Controller (IPFC), basic operating principles and characteristics. Applications of IPFC.

References / Suggested Text Books

1. NarainG.Hingorani, Laszio. Gyugy.L, "Understanding FACTS Concepts and Technology of Flexible AC Transmission Systems", Standard Publishers –Delhi 2001.
2. FACTS – Guilder
3. FACTS – Bhatnagar / Soni

EPE 615 ANN and Fuzzy Logic

	L	T	P
Credit	3	0	0
Hours	3	0	0

Neural Network: Introduction-biological neurons and their artificial models-learning, adaptation and neural network's learning rules types of neural networks-single layer, multiplayer-feed forward, feedback networks; back propagation learning and training-Hopfield network.

Neural Networks in Control: Neural network for non-linear systems-schemes of neuro control-system identification forward model and inverse model-indirect learning neural network control applications-case studies

Neural Network in Control: Structure of fuzzy logic controller-fuzzification models-data base-rule base-inference engine defuzzification module. Non-linear fuzzy control-PID like FLC-Sliding mode FLC - Surgeno FLC-adaptive fuzzy control-fuzzy control applications-case studies.

Analysis of Neural Networks: Analysis of Neural Network for liner and non-liner systems. Analysis of neuro -fuzzy systems. Application of neural networks

Fuzzy Logic: Fuzzy sets-fuzzy operation-fuzzy arithmetic-fuzzy relations-fuzzy relational equations-fuzzy measure-fuzzy functions-approximate reasoning-fuzzy propositions-fuzzy quantifiers-if-then rules. Adaptive Fuzzy control: Introduction, design & performance evaluation, performance monitor, main approaches to design. 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,

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. HELLENDOORN and M REINFRANK Narosa Publication House, 2nd reprint 1997.
5. Neural Network Design, - Hagan, Demuth Deak Thomson Learning

EPE 616 Analysis of Power Electronics Converter

	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 Modeling & Analysis of Electrical machine

	L	T	P
Credit	3	0	0
Hours	3	0	0

Basic principle of Electrical Machines: Introduction, Magnetically coupled circuit, Electromagnetic energy conversion, machine winding and air gap EMF, winding inductance and voltage equations, equation of transformation, Reference-Frame Theory.

Fundamental of Electrical Drives: Introduction, Choice of Electrical Drives, Dynamics of Electrical Drives, Concept of Multi-quadrant operation, Components of load torques, Selection of motor power rating, Speed torque, speed control, Starting, Braking.

Symmetrical Induction Machines: Introduction, voltage and torque equations in machine variables, voltage and torque equations in arbitrary reference frame, Analysis of steady state and dynamic operation.

Synchronous Machines: Introduction, voltage and torque equations in machine variables, voltage equations in rotor reference frame, Analysis of steady state and dynamic operation.

References / Suggested Text Books

1. P. C. Krause, OregWasynczuk, Scott D. SudhoffP.C.Krause, OregWasynczuk, Scott D. Sudhoff, "Analysis of Electric Machinery and drive systems" , IEEE Press, 2002.
2. P. S. Bhimbra, "Generalised Theory of Electrical Machines ", Khanna Publications 2013.
3. G. K. Dubey, "Fundamentals of Electrical Drives" Narosa, 2009.

4. G. K. Dubey, "Power Semiconductor Controlled Drives", Prentice Hall international, New Jersey, 1989.
5. R. Krishnan, “Electric Motor Drives Modeling, Analysis and Control” PHI-India, 2005.

EPE 618 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 621 Selected Topics in Power system and control

	L	T	P
Credit	2	0	1
Hours	2	0	2

Reactive Power flow and voltage stability in power systems: Physical relationship indicating dependency of voltage on reactive power flow - reactive power transient stability; Q-V curve; definition of voltage stability, voltage collapse and voltage security. Voltage collapse phenomenon, Factors of voltage collapse, effects of voltage collapse, voltage collapse analysis.

Voltage stability static indices : Development of voltage collapse index – power flow studies – singular value decomposition – minimum singular value of voltage collapse – condition number as voltage collapse index.

Voltage stability margins &Improvement of voltage stability: Stability margins, voltage stability margin of un compensated and compensated power system. Dynamic voltage stability – voltage security, Methods of improving voltage stability and its practical aspects.

References:

- Performance operation and control of EHV power transmission SystemsAchakrabarti, D.P.Kothari, A.K. Mukhopadhyay, A.H. Wheeler publishing, 1995.
- Power system Voltage stability - C.W. Taylor , Mc. Graw Hill, 1994

EPE 622 Utility Applications of Power Electronics

	L	T	P
Credit	2	0	1
Hours	2	0	2

Power Converters in Static Excitation Systems

HVDC Transmission: Basic scheme and equipment of converter station, 12 – pulse converter, converter unit, converter operation, fitters, reactive power source, ground return and ground electrode, Converter Circuits: Rectification and inversion, effect of reactance, six pulse and twelve pulse converter circuits; 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.

FACTS: 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

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, Elsivier, 2001.
4. Padiyar.K.R., FACTS CONTROLLERS IN POWER TRANSMISSION AND DISTRIBUTION, New Age International, 2007.

EPE 623 Analysis & control of Electrical drive systems

	L	T	P
Credit	3	0	0
Hours	3	0	0

DYNAMICS OF ELECTRIC DRIVES: 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 624 Wind Energy conversion system

	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 standards 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.
Maximum power point tracking-Methods, Generators and speed control used in wind power energy, Wind Power Control

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 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 626 Power Quality in distributed system

	L	T	P
Credit	3	0	0
Hours	3	0	0

Introduction to Power Quality : Voltage Quality, The power quality evaluation procedure-Need for a consistent-Vocabulary, General classes of power quality problems, Transients, Long-Duration voltage variations, Short-Duration voltage variations, Voltage Imbalance, waveform distortion, voltage fluctuation, Power frequency variations, Power quality terms

Voltage Sags and Interruptions: Sources of sags and interruptions-Estimating Voltage sag performance-Fundamental principles of protection-Solutions at the End-User level-Evaluating the economics of different ride_ through alternatives-Motor_ starting sags-Utility system fault_ clearing issues

Fundamentals of Harmonics: Harmonic Distortion-Voltage versus current distortion-Harmonic versus Transients-Power system Quantities under non sinusoidal conditions-Harmonic indices-Harmonic sources from commercial loads-Harmonic sources from industrial loads-Locating harmonic sources-System response characteristics-Effects of harmonic distortion- Inter harmonics

Applied Harmonics: Harmonic Distortion Evaluation-Principles of Controlling Harmonics-Where to control Harmonics? - Harmonic studies-Devices for controlling Harmonic Design- Harmonic filter Design.

Power Quality Monitoring and solutions: Monitoring considerations-Historical perspective of power quality measuring instruments-Power quality measurement equipment-Assessment of power quality measurement data-Application of intelligent systems-Power quality monitoring standards, Conventional and active power quality conditioners.

References / Suggested Text Books

1. Electrical power systems quality-Roger C.Dugan- McGraw- Hills
2. Power quality- C.Sankaran, CRC Press

EPE 627 Power System Reliability

	L	T	P
Credit	3	0	0
Hours	3	0	0

Basics of Probability theory & Distribution: Basic probability theory – rules for combining probabilities of events – Bernoulli's trials – probabilities density and distribution functions – binomial distribution – expected value and standard deviation of binomial distribution.

Network Modelling and Reliability Analysis: Analysis of Series, Parallel, Series-Parallel networks – complex networks – decomposition method.

Reliability functions:Reliability functions f(t), F(t), R(t), h(t) and their relationships – exponential distribution – Expected value and standard deviation of exponential distribution – Bath tub curve – reliability analysis of series parallel networks using exponential distribution – reliability measures MTTF, MTTR, MTBF.

Markov Modelling: Markov chains – concept of stochastic transitional probability Matrix, Evaluation of limiting state Probabilities. – Markov processes one component repairable system – time dependent probability evaluation using Laplace transform approach – evaluation of limiting state probabilities using STPM – two component repairable models.

Frequency & Duration Techniques: Frequency and duration concept – Evaluation of frequency of encountering state, mean cycletime, for one , two component repairable models – evaluation of cumulative probability and cumulative frequency of encountering of merged states.

Generation System Reliability Analysis: Reliability model of a generation system– recursive relation for unit addition and removal – load modeling - Merging of generation load model – evaluation of transition rates for merged state model – cumulative Probability, cumulative frequency of failure evaluation – LOLP, LOLE.

Composite Systems Reliability Analysis: Decompositions method – Reliability Indices – Weather Effects on Transmission Lines.

Distribution System and Reliability Analysis: Basic Concepts – Evaluation of Basic and performance reliability indices of radial networks.

Reference Books:

Reliability Evaluation of Engg. System – R. Billinton, R.N.Allan, Plenum Press, New York.

Reliability Evaluation of Power systems – R. Billinton, R.N.Allan, Pitman Advance Publishing Program, New York.

An Introduction to Reliability and Maintainability Engineering. Charles E. Ebeling, TATA McGraw- Hill – Edition.

Compulsory Courses: **PGS501** Library & Information service

PGS502 Technical writing and communication skill

EPE 631 Seminar

EPE632 Preliminery Examinations

EPE 633Thesis