DEPARTMENT OF ELECTRICAL ENGINEERING
College of Technology and Engineering, Udaipur-313001

SCHEME AND SYLLABUS

POST GRADUATE PROGRAMME

M. Tech. (Power Electronics)

(Effective from session: 2013-14)

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 **M. Tech. (Power Electronics)** in Electrical Engineering

S. No.	Title	Course No.	Cr. Hr.	Semester			
				I	II	III	IV-VI
Core Courses ***Masters Degree: Total 12 credits, two courses in first semester (6 credits) and one course in second and third semester (3 credits each) to be evaluated externally.***							
1	**Power System Operation and Control**	**EPE 511**	**3 (2+1)**	**3**	-	-	-
2	**Analysis of Power Electronic Converters**	**EPE 512**	**3 (2+1)**	**3**	-	-	-
3	Analysis & control of Electrical drive systems	EPE 521	3 (2+1)	-	3	-	-
4	Utility Application of Power Electronics	EPE 531	3 (2+1)	-	-	3	-
Major Courses Masters Degree: Total 15 credits, Two courses in first and second semester each (6 credits in each semester) and one course in third semester (3 credits).							
1	**Advanced Semiconductor devices**	**EPE 513**	**3 (3+0)**	**3**	-	-	-
2	**ANN and Fuzzy Logic**	**EPE 514**	**3 (3+0)**	**3**	-	-	-
3	Wind Energy conversion system	EPE 522	3 (3+0)	-	3	-	-
4	Advanced Power Converters	EPE 523	3 (3+0)	-	3	-	-
5	Modern control techniques in electrical drives	EPE 532	3 (3+0)	-	-	3	-
Minor/Supporting Courses ***Masters Degree: Total 9 credits, one course in first, second and third semester each (3 credits in each semester).***							
1	**System Theory**	**EPE 515**	**3 (3+0)**	**3**	-	-	-
2	Modeling & Analysis of Electrical machine	EPE 516	3 (3+0)	3	-	-	-
3	CAD/ CAM	MED 518	3 (3+0)	3	-	-	-
4	Advance Programming with C++	CSE 511	3 (2+1)	3	-	-	-
5	Energy Audit and Management	RES 515	3 (2+1)	3	-	-	-
6	Computer aided power system analysis	EPE524	3 (3+0)	-	3	-	-
7	Methods of Numerical Analysis	BS 521	3 (3+0)	-	3	-	-
8	Alternate Fuels and Applications	RES 524	3 (3+0)	-	3	-	-
9	Design and Analysis of Renewable Energy Conversion Systems	RES 522	3 (3+0)	-	3	-	-
10	High Voltage dc Transmission system	EPE 533	3 (3+0)	-	-	3	-
11	Industrial Automation and Control	EPE534	3 (3+0)	-	-	3	-
Others							
	Compulsory Courses						
	Library & Information service	PGS501	NC	3	-	-	-
	Technical writing and communication skill	PGS502	NC	-	3	-	-
	Seminar	EPE 535	1 (0+1)	-	-	1	-
	Preliminery Examinations (Oral and written)	EPE 540	Non Credit	-	-	Non Credit	-
	Thesis*	EPE 541	20 (0+20)	-	-	-	20
	Total Credit Hours M. Tech. (57)			15	12	10	20

Course Summary
Masters Programme

Courses	No. of Courses					Credit Hours
	Semester					
	I	II	III	IV	Total	
Core	2	1	1	-	4	12
Major	2	2	1	-	5	15
Minor/Supporting	1	1	1	-	3	9
Seminar	-	-	1	-	1	1
Research Project	-	-	-	1	1	20
Compulsory Courses	1	1	-	-	2	Non Credit
Total	**6**	**5**	**4**	**1**	**16**	**57**

POST GRADUATE PROGRAM 2013-14

SYLLABUS
(Specialization in Power Electronics)

EPE 511 Power System Operations and Control

	L	T	P
Credit	2	0	1
Hours	2	0	2

Introduction (Characteristics of Modern Power Systems): Physical Structure, Operation and Control Functions and Hierarchies, Design and Operating Criteria.
Equipment and Stability Constraints, Capabilities and Constraints of Generators/Exciters/Turbines/Network Elements (Lines, Transformers etc.) Constraints of Energy Supply Systems, Load Characteristics Introduction to Angle/Voltage Instability phenomena Stability Constraints.
Frequency and Voltage Control: Primary Control of Frequency-Governors Secondary Control of Frequency- AGC.
Voltage control: Automatic Voltage Regulators (generators), Shunt Compensation, SVC Introduction to Power Flow Control- HVDC, FACTS Load Curves Unit Commitment Introduction to the use of Optimization Methods.
Load Dispatch Centre Functions: Contingency Analysis Preventive, Emergency and Restorative Control.

Reference Books:

1. Electrical Energy Systems Theory - by O.I.Elgerd, Tata McGraw-Hill Publishing Company Ltd, 2nd edition.
2. Power System Analysis by HadiSaadat – Tata McGraw Hill Publications
3. Power Generation, Operation and Control - by A.J.Wood and B.F.Wollenberg,John wiley& sons Inc. 1984.
4. Modern Power System Analysis - by I.J.Nagrath&D.P.Kothari, Tata McGraw-Hill Publishing Company ltd, 2nd edition.

EPE 512 Analysis of Power Electronic Converters

	L	T	P
Credit	2	0	1
Hours	2	0	2

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 513 Advanced Semiconductor devices

	L	T	P
Credit	3	0	0
Hours	3	0	0

Structure and Construction, Working and operations, Switching and Static Characteristics , Ratings, Triggering Circuits, Protection Circuits, Commutation Circuits, PSPICE Models, Testing, Gate Drive Requirements and Applications of various Power Switching Devices, *i.e.* SCR, GTO, MOSFETS, BJT, IGBT, MCTs, and Static Induction Devices .

Trigger Techniques, Optical Isolators, Protection Circuits, Isolation Transformers, Future Trends in Power Devices, Comparison Testing of Switches, General Power Semiconductor Switch Requirements.

Text and Reference books:

1. Power electronics – N. Mohan ,John Wiley student edition, Singapore
2. Power electronics and A C Drives – B. K. Bose, Pearson, India
3. Power electronics : circuits, drives and applications – H Rashid, , Pearson, India
4. Power electronics Devices – P. C. Sen, TMH, India

EPE 514 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
6. Neuro-fuzzy and soft computing, PHI publication
7. Fuzzy logic : Intelligence control and Information, - John Yen Pearson publication.

EPE 515 System Theory

	L	T	P
Credit	3	0	0
Hours	3	0	0

State Space Analysis: Concept of state, state space representation of systems, phase variable form, canonical variable form, physical variable form, Diagonalization, relationship between state equation and transfer function, solution of state equation, concept of controllability and observability, eigen values and eigen vector.

Sampled Data System: importance of sampling, mathematical analysis of sampling, spectrum analysis of sampling process, Shanon's Theorem, signal reconstruction, hold circuit, Z transform, inverse Z transform, difference equation, pulse transfer function, state variable representation of sampled data system, solution of discrete state equation.

Non Linear system: characteristic of nonlinear system, type of Non linearity, jump resonance, limit cycle, describing function method of analysis.

LiapunovStability Criteria: Introduction, stability definitions and theorems, Liapunov function for linear system.

References / Suggested Text Books

1. Nagrath& M. Gopal, "Control System Engineering", New Age International Publications, 2009
2. B. S. Manke, "Control System Design" Khanna Publications, 2011.
3. Ogata, "Modern Control Engineering" Pearson Education, 2008.
4. D. Roy Choudhary, "Modern Control Engineering", DhanpatRai& Sons Publication, 2008.

	L	T	P
Credit	3	0	0
Hours	3	0	0

EPE 516 Modeling & Analysis of Electrical machine

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 521 Analysis & control of Electrical drive systems

	L	T	P
Credit	2	0	1
Hours	2	0	2

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 522 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 523 Advanced Power Converters

	L	T	P
Credit	3	0	0
Hours	3	0	0

Single-Switch Isolated Converters: Requirement for isolation in the switch-mode converters, transformer connection, Forward and flyback converters, power circuit and steady-state analysis. Push-Pull Converters-Power circuit and steady-state analysis, utilization of magnetic circuits in single switch and push-pull topologies.

Dynamic Analysis of DC-DC Converters: Formulation of dynamic equation of buck and boost converters, averaged circuit models, linearization technique, small-signal model and converter transfer functions.

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

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

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.
4. Fundamentals of Power Electronics – Robert Erickson and Dragon Maksivimovic,
5. Springer Publications. Power Electronics–IssaBatarseh- John Wiely
6. Elements of Power Electronics - Philip T.Krein – Oxford University Press

EPE 524 Computer aided power system analysis

	L	T	P
Credit	3	0	0
Hours	3	0	0

MATLAB: Introduction, functions, string, array, operator, entering, matrices control flow, M-files, graphics, two dimension, mesh, surface, contour plot, graphics of polar system, application of MATLAB numerical techniques, curve fitting, polynomial. Application of various toolboxes viz. Control system toolbox, Neural Network toolbox, Fuzzy logic toolbox, signal processing toolbox. Applied Numerical analysis: Roots of polynomial equations, Newton Raphson method for non linear equations. Numerical differentiation & integration: - Newton-Cotes Gaussian type quadrature methods. Fourier series and Fourier transform. FFT, DFT concepts & their applications in harmonic analysis.

Text and Reference Books:

1. MATLAB – Rudrapratap
2. Numerical analysis – Shastry

EPE 531 Utility Application of Power Electronics

	L	T	P
Credit	2	0	1
Hours	2	0	2

Overview of 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 532 MODERN CONTROL TECHNIQUES IN ELECTRIC DRIVES

	L	T	P
Credit	3	0	0
Hours	3	0	0

Vector Control of Induction Motor: Principles of vector control, Direct vector control, derivation of indirect vector control, implementation-block diagram; estimation of flux, flux weakening operation.

Sensorless Vector Control of Induction Motor: Slip and speed estimation at low performance, rotor angle and flux linkage estimation at high performance-rotor speed estimation scheme-estimators using rotor slot harmonics, model reference adaptive systems, extended Kalamn filter, injection of auxiliary signal on salient rotor.

Control of Synchronous Motor Drives: Synchronous motor and its characteristics- Control strategies-Constant torque angle control- power factor control, constant flux control, flux weakening operation, Load commutated inverter fed synchronous motor drive, motoring and regeneration, phasor diagrams.

Control of Switched Reluctance Motor Drives: SRM Structure-Stator Excitation-techniques of sensor less operation-convertor topologies-SRM Waveforms-SRM drive design factors-Torque controlled SRM-Torque Ripple-Instantaneous Torque control -using current controllers-flux controllers.

Control of BLDC Motor Drives: Principle of operation of BLDC Machine, Sensing and logic switching scheme, BLDM as Variable Speed Synchronous motor-methods of reducing Torque pulsations -Three-phase full wave Brushless dc motor -Sinusoidal type of Brushless dc motor - current controlled Brushless dc motor Servo drive.

References / Suggested Text Books

1. Electric Motor Drives Modeling, Analysis & control -R. Krishnan- Pearson Education
2. Modern Power Electronics and AC Drives –B. K. Bose-Pearson Publications
3. Sensorless Vector Direct Torque control –Peter Vas, Oxford University Press
4. Modern Power Electronics and AC Drives –B. K. Bose-Pearson Publications-
5. Power Electronics control of AC motors – MD Murphy & FG Turn Bull Pergman Press -1st edition-1998.
6. Fundamentals of Electrical Drives – G.K. Dubey – Narosa Publications -1995
7. Power Semiconductor drives- G.K. Dubey-Prentice hall

EPE 533 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, fitters, 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 534 Industrial Automation and Control

	L	T	P
Credit	3	0	0
Hours	3	0	0

Introduction to Industrial Automation and Control, Architecture of Industrial Automation Systems, Introduction to sensors and measurement systems, Temperature measurement, Pressure and Force measurements, Displacement and speed measurement, Flow measurement techniques, Measurement of level etc.

Signal Conditioning and Processing, Estimation of errors and Calibration

Introduction to Process Control, Control structures and performance measures, Time and frequency domain performance measures, Design of controller, P-I-D Control, Controller Tuning, Implementation of PID Controllers, Limitations of PID controllers, Identification of dynamic models of plants

Reference Book:

1. S. Majhi,Advanced Control Theory-Relay Feedback Approach, Cengage Asia/India Pvt.Ltd, 2009.
2. A. Johnson and H. Moradi, New Identifications and Design Methods,Springer - Verlag, 2005.
3. Norman S. Nise, Control Systems Engineering, John Wiley & Sons, 2008
4. Patranabis, Principles of Industrial Instrumentation Tata McGraw Hill Publishing Co., New Delhi, 1999
5. R.K.Jain, Mechanical and Industrial Measurements, Khanna Publishers, Delhi 1999.
6. A.K.Sawhney, A course in Electrical and Electronic Measurement and Instrumentation – Dhanpat Rai and Sons, New Delhi, 1999.

Compulsory Courses

EPE 535 Seminar

EPE 541Thesis