M.TECH. POWER ELECTRONICS (EPE)

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM

SCHEME OF TEACHING AND EXAMINATION FOR

M.TECH. POWER ELECTRONICS (EPE)

(2014-16)

I Semester **Credit Based**

Subject Code	Name of the Subject	Teaching hours/week		Duration of Exam in Hours	Marks for		Total Marks	Credits
		Lecture	Practical / Field Work / Assignment/ Tutorials		I.A.	Exam		
12MAT11	Applied Mathematics	4	2	3	50	100	150	4
14 EPE 12	Power Semiconductor Devices	4	2	3	50	100	150	4
14 EPE 13	Modeling and Simulation of Power Electronic Systems	4	2	3	50	100	150	4
14 EPE 14	Solid State Power Controllers	4	2	3	50	100	150	4
14 EPE 15X	Elective-I	4	2	3	50	100	150	4
14 EPE 16	Power Electronics Laboratory - I	--	3	3	25	50	75	2
14 EPE 17	Seminar	--	3	--	25	--	25	1
	Total	**20**	**16**	**18**	**300**	**550**	**850**	**23**

Elective – I

Subject Code	Name of the Subject
14EPE151	Embedded System Design
14EPE152	Soft Computing
14EPE153	Advanced Control Systems

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II Semester **Credit Based**

Subject Code	Name of the Subject	Teaching hours/week		Duration of Exam in Hours	Marks for		Total Marks	Credits
		Lecture	Practical / Field Work / Assignment/ Tutorials		IA	Exam		
14EPE21	AC and DC Drives	4	2	3	50	100	150	4
14 EPE 22	Switched Mode Power Conversion	4	2	3	50	100	150	4
14 EPE 23	Power Electronics System Design using ICs	4	2	3	50	100	150	4
14 EPE24	FACTS Controllers	4	2	3	50	100	150	4
14 EPE 25X	Elective-II	4	2	3	50	100	150	4
14 EPE 26	Power Electronics Laboratory - II		3	3	25	50	75	2
14 EPE 27	Seminar	--	3	--	25	--	25	1
	**Project Phase-I (6 week Duration)	--	--	--	--	--	--	--
	Total	**20**	**16**	**18**	**300**	**550**	**850**	**23**

**** Between the II Semester and III Semester, after availing a vacation of 2 weeks.**

Elective – II

Subject Code	Name of the Subject
14EPE251	Real Time Digital Signal Processing
14EPE252	Modeling and Analysis of Electrical Machines
14EPE253	Electro Magnetic Compatibility

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III Semester: INTERNSHIP								**Credit Based**
Course Code	**Subject**	**No. of Hrs./Week**		**Duration of Exam in Hours**	**Marks for**		**Total Marks**	**Credits**
		Lecture	**Practical/ Field Work**		**IA**	**Exam**		
14EPE31	Seminar/Presentation on Internship (After 8 weeks from the date of commencement)	--	--	--	25	--	25	1
14EPE32	Report on Internship	--	--	--	--	75	75	15
14EPE33	Evaluation and Viva-Voce	--	--	--	--	50	50	4
	Total	**--**	**--**	**--**	**25**	**125**	**150**	**20**

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IV Semester | Credit Based

Subject Code	Subject	No. of Hrs./Week		Duration of Exam in Hours	Marks for		Total Marks	Credits
		Lecture	Field Work / Assignment / Tutorials		IA	Exam		
14EPE41	HVDC power Transmission	4	--	3	50	100	150	4
14EPE 42X	Elective-III	4	--	3	50	100	150	4
14EPE43	Evaluation of Project Phase – II	--	--	--	25	--	25	1
14EPE44	Evaluation of Project work – III	--	--	--	25	--	25	1
14EPE45	Evaluation of Project Work and Viva-voce	--	--	3	–	100+100	200	18
	Total	8	--	09	50	400	550	28

Grand Total (I to IV Sem.) : 2400 Marks; 94 Credits

Elective - III

Subject code	**Name of the Subject**
14EPE421	Power Quality Enhancement using Custom Power Devices
14EPE422	PWM Converters and Applications
14EPE423	DSP Applications to Drives

Note:

1) Project Phase – I:6 weeks duration shall be carried out between II and III Semesters. Candidates in consultation with the guides shall carryout literature survey / visit to Industries to finalise the topic of dissertation.

2) Project Phase – II:16 weeks duration. 3 days for project work in a week during III Semester. Evaluation shall be taken during the first two weeks of the IV Semester. Total Marks shall be 25.

3) Project Phase – III :24 weeks duration in IV Semester. Evaluation shall be taken up during the middle of IV Semester. At the end of the semester Project Work evaluation and Viva-Voce Examinations shall be conducted.

   Total Marks shall be 250 (Phase - II Evaluation: 25 Marks, Phase – III Evaluation:25 Marks, Project Evaluation marks by Internal Examiner (Guide):50, Project Evaluation marks by External Examiner :50, Viva-Voce Examination:100 Marks).

   Marks of Evaluation of Project:

   - The I.A. Marks of Project Phase – II & III shall be sent to the University along with Project Work report at the end of the Semester.

4) During the final viva, students have to submit all the reports.

5) The Project Valuation and Viva-Voce will be conducted by a committee consisting of the following:

   a) Head of the Department (Chairman)
   b) Guide
   c) Two Examiners appointed by the university (Out of two external examiners at least one should be present).

M.TECH. POWER ELECTRONICS (EPE) SEMESTER - I			
APPLIED MATHEMATICS			
Subject Code	14MAT11	IA Marks	50
No. of Lecture Hours/Week	04	Exam Hours	03
Number of Practical Hours/week	--	Number of Tutorial Hours/week	02
Total No. of Lecture Hours	52	Exam Marks	100

Numerical Methods: Solution of algebraic and transcendental equations- iterative methods based on second degree equation – Muller method,(no derivation) Chebyshev method, general iteration method (first order),acceleration of convergence, system of non-linear equations, and complex roots – Newton-Raphson method, polynomial equations – Birge –Vieta method and Bairstow's method.

Numerical Solution of Partial Differential Equations: Classification of second order equations, parabolic equations- solution of one dimensional heat equation, explicit method,Crank-Nicolson method and Du Fort-Frankel method, hyperbolic equations- solution of one dimensional wave equation.

System of Linear Algebraic Equations and Eigen Value Problems: Iterative methods - Gauss-Seidal method, SOR method, Eigen value problems – Gerschgorian circle, Eigen values and Eigen vectors of real symmetric matrices -Jacobi method, Givens method.

Interpolation: Hermite interpolation, spline interpolation, numerical solution of differential equations – Numerov method.

Optimization: Linear programming- formulation of the problem, graphical method, general linear programming problem, simplex method, artificial variable technique -M-method.

Graph Theory: Basic terminologies, types of graphs, sub graphs, graphs isomorphism, connected graphs-walks, paths, circuits, connected and disconnected graphs, operations on graphs, Eulerian paths and circuits, Hamiltonian paths and circuits, applications of graphs.

Linear Algebra: Vector spaces, linear dependent, independence, basis and dimension, elementary properties, examples.
Linear Transformations: Definition, properties, range and null space, rank and nullity, algebra of linear transformations- invertible, singular and non-singular transformations, representation of transformations by matrices.

REFERENCE BOOKS

1. M K Jain, S R K Iyengar and R K Jain, "Numerical Methods for Scientific and Engineering Computations", New Age International, 2004.
2. M K Jain, "Numerical Solution of Differential Equations", 2ndEdition, New Age International, 2008.
3. Dr. B.S. Grewal, "Numerical Methods in Engineering and Science", Khanna Publishers, 1999.
4. Dr. B.S. Grewal, "Higher Engineering Mathematics", 41stEdition, Khanna Publishers, 2011.
5. NarsinghDeo, "Graph Theory with Applications to Engineering and Computer Science", PHI, 2012.
6. Kenneth Hoffman and Ray Kunze, "Linear Algebra", 2ndEdition, PHI, 2011.

M.TECH. POWER ELECTRONICS (EPE) **SEMESTER - I**			
POWER SEMICONDUCTOR DEVICES			
Subject Code	14EPE12	IA Marks	50
No. of Lecture Hours/Week	04	Exam Hours	03
Number of Practical Hours/week	02	Number of Tutorial Hours/week	--
Total No. of Lecture Hours	52	Exam Marks	100

Power Diodes: Basic structure and V-I characteristics, breakdown voltages and control, on-state losses, switching characteristics-turn-on transient, turn-off transient and reverse recovery transient, Schottky diodes, snubber requirements for diodes, diode snubber, modeling and simulation of power diodes.

Thyristors:- Basic structure, V-I characteristics, turn-on process, on-state operation, turn -off process, switching characteristics, turn-on transient and di/dt limitations, turn-off transient, turn-off time and reapplied dv/dt limitations, gate drive requirements, ratings of thyristors, snubber requirements and snubber design, modeling and simulation of thyristors.

Triacs: Basic structure and operation-I characteristics, ratings, snubber requirements, modeling and simulation of triacs**.**
Gate Turnoff Thyristor (GTO): Basic structure and operation, GTO switching characteristics, GTO turn-on transient, GTO turn -off transient, minimum on and off state times, gate drive requiremen**ts,** maximum controllable anode current, overcurrent protection of GTO'S, modelling and simulation of GTO'S.

Power BJT'S: Basic structure and V-I characteristics, breakdown voltages and control, secondary breakdown and it's control- FBSOA and RBSOA curves - on state losses, switching characteristics, resistive switching specifications, clamped inductive switching specifications, turn-on transient, turn-off transient, storage time, base drive requirements, switching losses, device protection- snubber requirements for BJT'S and snubber design - switching aids, modeling and simulation of power BJT'S.

Power MOSFET'S:- Basic structure, V-I characteristics, turn-on process, on state operation, turn-off process, switching characteristics, resistive switching specifications, clamped inductive switching specifications - turn-on transient and di/dt limitations, turn-off transient, turn off time, switching losses, effect of reverse recovery transients on switching stresses and losses - dv/dt limitations, gating requirements, gate charge - ratings of MOSFET'S, FBSOA and RBSOA curves, device protection -snubber requirements, modeling and simulation of Power MOSFET'S.
Insulated Gate Bipolar Transistors (IGBT'S): Basic structure and operation, latch up IGBT, switching characteristics, resistive switching specifications, clamped inductive switching specifications - IGBT turn-on transient, IGBT turn off transient- current tailing - gating requirements -ratings of IGBT'S, FBSOA and RBSOA curves, switching losses - minimum on and off state times - switching frequency capability - overcurrent protection of IGBT'S, short circuit protection, snubber requirements and snubber design.

New Power Semiconductor Devices : MOS gated thyristors, MOS controlled thyristors or MOS GTO'S, base resistance controlled thyristors, emitter switched thyristor, thermal design of power electronic equipment, modeling and simulation, heat transfer by conduction, transient thermal impedance - heat sinks, heat transfer by radiation and convection - heat sink selection for power semiconductor devices.

REFERENCE BOOKS

1. Ned Mohan, Tore M. Undeland, William P. Robbins, "Power Electronics Converters, Applications, and Design", 3rdEdition. Wiley India Pvt Ltd, 2011.
2. G. Massobrio, P. Antognetti, "Semiconductor Device Modeling with Spice", McGraw-Hill, 2nd Edition, 2010.
3. B. JayantBaliga, "Power Semiconductor Devices", 1stEdition,International Thompson Computer Press, 1995.
4. V. Benda, J. Gowar, and D. A. Grant, "Discrete and Integrated Power Semiconductor Devices: Theory and Applications", John Wiley & Sons, 1999.

M.TECH. POWER ELECTRONICS (EPE) SEMESTER - I			
MODELING AND SIMULATION OF POWER ELECTRONIC SYSTEMS			
Subject Code	14EPE13	IA Marks	50
No. of Lecture Hours/Week	04	Exam Hours	03
Number of Practical Hours/week	02	Number of Tutorial Hours/week	--
Total No. of Lecture Hours	52	Exam Marks	100

Computer Simulation of Power Electronic Converters and Systems: Challenges in computer simulation, simulation process, Types of analysis, mechanics of simulation, circuit-oriented simulators, equation solvers, comparison of circuit oriented simulators and equation solvers.

Modeling of Systems: Input-Output relations, differential equations and linearization, state space representation, transfer function representation, modeling of an armature controlled DC Motor, poles and zeros circuit averaging method of modelling approach for switched power electronic circuits, space vector modeling, space vectors, representation of space vectors in orthogonal co-ordinates, space vector transformations, modeling of induction motor, state space representation of the d-q model of the induction motor.

Digital Controller Design: Controller design techniques, Bode diagram method, PID controller, design, root locus method, state space method. Tracker, controller design, controlling voltage, controlling current.

Discrete Computation Essentials: Numeric formats, fixed -point numeric format, floating -point numeric format, tracking the base point in the fixed point system, addition of numbers, subtraction of numbers, multiplication of numbers, normalization and scaling, multiplication algorithm, arithmetic algorithm reciprocal, square root, reciprocal of square root, sine and cosine exponential, logarithm, implementation examples, pi controller, sine and cosine, pulse width modulation, space vector pwm, over-modulation.

REFERENCE BOOKS

1 .Ned Mohan, Tore M. Undeland, William P. Robbins, “Power Electronics Converters, Applications, and Design”, 3 rd Edition, John Wiley & Sons, 2009.
2. L.Umanand,"Power Electronics Essentials and Applications",1st Edition, John Wiley & Sons, 2009.

M.TECH. POWER ELECTRONICS (EPE) SEMESTER - I			
SOLID STATE POWER CONTROLLERS			
Subject Code	14EPE14	IA Marks	50
No. of Lecture Hours/Week	04	Exam Hours	03
Number of Practical Hours/week	02	Number of Tutorial Hours/week	--
Total No. of Lecture Hours	52	Exam Marks	100

Line Commutated Converters: Phase control, single phase semi-converter & fully controlled converter, three phase semi controlled & fully controlled converter, dual converters, power factor improvement methods, effect of source inductance, single phase series converters, twelve pulse converter and design of converter circuits.

Inverters: Principle of operation, performance parameters, single phase bridge inverters and three phase inverters.

Voltage Control of Single Phase Inverters: Single/multiple, pulse/SPWM/ modified SPWM methods, voltage control of three phase inverter, SPWM/third harmonic PWM/Space vector modulation, harmonic reduction, current source inverter, comparison between VSI & CSI.

Multilevel Inverters: Introduction, types, diode clamped multi-level inverters, features & applications.

DC-DC Converters: Principle of operation, analysis of step-down and step-up converters, classification of chopper & chopper circuit design.

REFERENCE BOOKS

1. Ned Mohan, Tore M. Undeland, William P. Robbins, "Power Electronics Converters, Applications, and Design", 3rd Edition,Wiley India Pvt Ltd, 2011
2. Rashid M.H,"Power Electronics: Circuits Devices and Applications",3rd Edition, Pearson,2011.
3. B. K. Bose, "Modern Power Electronics & AC Drives", PHI,2012.

M.TECH. POWER ELECTRONICS (EPE) SEMESTER - I			
EMBEDDED SYSTEM DESIGN(ELECTIVE-I)			
Subject Code	14EPE151	IA Marks	50
No. of Lecture Hours/Week	04	Exam Hours	03
Number of Practical Hours/week	--	Number of Tutorial Hours/week	02
Total No. of Lecture Hours	52	Exam Marks	100

Introduction to Embedded System: An embedded system, processor, hardware unit, software embedded into a system, example of an embedded system, OS services, I/O, N/W, O/S, real time and embedded OS.

Processor and Memory Organization: Structural unit in a processor, processor selection for an embedded systems, memory devices, memory selection for an embedded system, allocation of memory to program statements and blocks and memory map of a system, direct memory accesses.

Real Time System: Types, real time computing, design issues, sample systems, hardware requirements- processor introduction, ARM various system architecture, high performance processors - strong ARM processors, addressing modes, instruction set, basic alp programs, interrupt structure.

Real Time Operating System: Fundamental requirements of RTOS, real time kernel types, schedulers, various scheduling modules with examples, latency (interrupt latency, scheduling latency and context switching latency), tasks, state transition diagram, task control block. Inter-task communication and synchronization of tasks, building real time applications.

REFERENCE BOOKS

1. Rajkamal "Embedded System Architecture: Programming & Design",
TMH, 2010.
2. David E. Simon, "An Embedded Software Primer", Pearson Education,
1999.
3. Philip. A. Laplante, "Real-Time Systems Design and Analysis- An Engineer's Handbook"- 2^{nd}Edition, Pearson.
4. Jane W.S. Liu, "Real-Time Systems", Pearson Education Inc,2012.
5. K.V.K K Prasad, "Embedded Real Time Systems: Concepts Design and Programming", Dreamtech Press New Delhi, 2003.

M.TECH. POWER ELECTRONICS (EPE) SEMESTER - I			
SOFT COMPUTING(ELECTIVE-I)			
Subject Code	14EPE152	IA Marks	50
No. of Lecture Hours/Week	04	Exam Hours	03
Number of Practical Hours/week	--	Number of Tutorial Hours/week	02
Total No. of Lecture Hours	52	Exam Marks	100

Learning and Soft Computing: Examples, basic tools of soft computing, basic mathematics of soft computing, learning and statistical approaches to regression and classification.

Single-Layer Networks: Perceptron, Adaptive linear neuron (Adaline), and the LMS algorithm.
Multilayer Perceptrons: Error back propagation algorithm, generalized delta rule, practical aspects of error back propagation algorithm.

Radial Basis Function Networks: Ill-posed problems and the regularization technique, stabilizers and basis functions, generalized radial basis function networks.

Fuzzy Logic Systems: Basics of fuzzy logic theory, mathematical similarities between neural networks and fuzzy logic models, fuzzy additive models.

Support Vector Machines: Risk minimization principles and the concept of uniform convergence, VC dimension, structural risk minimization, support vector machine algorithms.
Case Studies: Neural-network based adaptive control, computer graphics.

REFERENCE BOOKS

1. Vojislav Kecman, “Learning and Soft Computing”, Pearson Education (Asia) Pvt. Ltd. 2004.
2. Simon Haykin, "Neural Networks: A Comprehensive Foundation", Pearson Education (Asia) Pvt. Ltd., Prentice Hall of India, 2008.
3. M.T. Hagan, H.B. Demuth and M. Beale, "Neural Network Design", Thomson Learning, 2002.
4. Bart Kosko, "Neural Networks and Fuzzy Systems",Prentice Hall of India, 2010.
5. George J. Klir and Bo Yuan, "Fuzzy Sets and Fuzzy Logic: Theory and Application", PHI, 2012.

M.TECH. POWER ELECTRONICS (EPE) SEMESTER - I			
ADVANCED CONTROL SYSTEMS(ELECTIVE-I)			
Subject Code	14EPE153	IA Marks	50
No. of Lecture Hours/Week	04	Exam Hours	03
Number of Practical Hours/week	--	Number of Tutorial Hours/week	02
Total No. of Lecture Hours	52	Exam Marks	100

Digital Control Systems: Review of difference equations and Z - transforms, Z- transfer function (Pulse transfer function), Z - Transforms analysis, sampled data systems, stability analysis (Jury's Stability Test and Bilinear Transformation), pulse transfer functions and different configurations for closed loop discrete-time control systems.

Modern Control Theory: State model for continuous time and discrete time systems, solutions of state equations (for both continuous and discrete systems), concepts of controllability and observability (for both continuous and discrete systems), pole placement by state feedback (for both continuous and discrete systems), full order and reduced order observes (for both continuous and discrete systems), dead beat control by state feedback, optimal control problems using state variable approach, state regulator and output regulator, concepts of model reference control systems, adaptive control systems and design.

Non Linear Control Systems: Common nonlinearities, singular points, stability of nonlinear systems - phase plane analysis and describing function analysis, Lyapunov's stability criterion, Popov's criterion.

REFERENCE BOOKS

1. Ogata. K. "Modern Control Engineering", 5th Edition, PHI, 2010.
2. Ogata K "Discrete Time Control Systems", 2nd Edition, PHI, 2011.
3. Nagarath and Gopal, "Control Systems Engineering", New Age International Publishers, 2012.
4. M Gopal "Modem Control System Theory", New Age International,2011.
5. M. Gopal, "Digital Control & State Variable Methods", TMH, 2011.

M.TECH. POWER ELECTRONICS (EPE) SEMESTER - I			
POWER ELECTRONICS LABORATORY - I			
Subject Code	14EPE16	IA Marks	25
No. of Lecture Hours/Week	--	Exam Hours	03
Number of Practical Hours/week	03	Number of Tutorial Hours/week	--
Total No. of Lecture Hours	--	Exam Marks	50

1. Analysis of static and dynamic characteristic of MOSFET and IGBT
2. Performance of single phase fully controlled and semi-controlled converter for RL load for continuous current mode
3. Performance of single phase fully controlled and semi-controlled converter for RL load for discontinuous current mode
4. Study of effect of source inductance on the performance of single phase fully controlled converter
5. Performance analysis of three phase fully controlled and semi-controlled converter for RL load for continuous current mode
6. Performance analysis of three phase fully controlled and semi-controlled converter for RL load for discontinuous current mode
7. Performance analysis of single phase bridge inverter for RL load and voltage control by single pulse width modulation
8. Performance analysis of two quadrant chopper
9. Diode clamped multilevel inverter
10. ZVS operation of a Synchronous buck converter

M.TECH. POWER ELECTRONICS (EPE) SEMESTER - I			
SEMINAR			
Subject Code	14EPE17	IA Marks	25
No. of Lecture Hours/Week	--	Exam Hours	--
Number of contact Hours/week	03	Number of Tutorial Hours/week	--
Total No. of contactHours	--	Exam Marks	--

The aim of the seminar is to inculcate self-learning, face audience, enhance communication skill, involve in group discussion and present his ideas.

Each student, under the guidance of a Faculty, is required to

- i) Choose a topic of his/her interest relevant to the Course of Specialization
- ii) Carryout literature survey, organize the subject topics in a systematic order
- iii) Prepare the report with own sentences
- iv) Type the matter to acquaint with the use of Micro-soft equation and drawing tools or any such facilities
- v) Present the seminar topic at least for 20 minutes orally and/or through power point slides
- vi) Answer the queries and involve in debate/discussion lasting for about 10 minutes
- vii) Submit two copies of the typed report with a list of references

The participants shall take part in discussion to foster friendly and stimulating environment in which the students are motivated to reach high standards and become self-confident.

The internal assessment marks shall be awarded by a committee consisting of at least two staff members based on the relevance of the topic, presentation skill, participation in the question and answer session and quality of report.

M.TECH. POWER ELECTRONICS (EPE) SEMESTER - II			
ACANDDC DRIVES			
Subject Code	14EPE21	IA Marks	50
No. of Lecture Hours/Week	04	Exam Hours	03
Number of Practical Hours/week	02	Number of Tutorial Hours/week	--
Total No. of Lecture Hours	52	Exam Marks	100

Electric Drives: Introduction – block diagram-classification of electrical drives-choice of electrical drives- fundamental torque equation- components of load torque- steady state stability.

DC Drives: Single Quadrant Drive: 1-Phase semi and half wave converter drives,Two quadrant Drive: 1-phase and 3-phase full converter drive.
Two and Four Quadrant drive: 1-phase and three- phase dual converter drive, different braking methods and closed loop control of DC drives.

AC Drives:Voltage and current source inverter - inverter control-six step and PWM operation, Control of Induction motor drive -V/f and field oriented control – direct and indirect vector control,voltage and current source inverter fed induction motor drives,stator and rotor voltage control methods, slip energy recovery drives.

Closed Loop Control of AC Drives: Stator voltage control,V/f control, slip regulation, speed control of static Kramer's drive, current control, brushless DC motor, stepper motor and variable reluctance motor drives static excitation schemes of AC generator.

REFERENCE BOOKS

1. Bose B. K, "Modern Power Electronics & AC Drives" PHI, 2011.
2. Murphy JMD, Turnbull F.G., "Thyristor Control of AC Motors" Pergamon Press Oxford, 1998.
3. R.Krishanan "Electric Motor Drives", EEE, PHI, 2010.
4. MehrdadEhsani, YiminGao, AlinEmadi, "Modern Electric, Hybrid Electric and Fuel Cell Vehicle Fundamentals, Theory and Design" SpecialIndian Edition, CRC Press 2011.
5. High Performance Control of AC Drives "Haitham Abu-Rub,AtifIqbal, JaroslawGuzinski, Wiley, 2012.

M.TECH. POWER ELECTRONICS (EPE) SEMESTER - II			
SWITCHED MODE POWER CONVERSION			
Subject Code	14EPE22	IA Marks	50
No. of Lecture Hours/Week	04	Exam Hours	03
Number of Practical Hours/week	02	Number of Tutorial Hours/week	--
Total No. of Lecture Hours	52	Exam Marks	100

DC – DC Converters (Basic Converters): Linear voltage regulators (LVRs), a basic switching converter(SMPC), comparison between LVR & SMPC, principle of operation and analysis of buck converter analysis, inductor current ripple and output voltage ripple, capacitor resistance effect, synchronous rectification, design considerations, buck converter for discontinuous current operation, principle of operation and analysis of boost converter, inductor current ripple and output voltage ripple, inductor resistance effect, design considerations, boost converter for discontinuous current operation,principle of operation and analysis of buck-boost converter analysis, inductors current ripple and output voltage ripple, design considerations, buck-boost converter for discontinuous current operation, principle of operation and analysis of CUK converter , inductor current ripple and output voltage ripple, capacitor resistance effect, design considerations, single ended primary inductance converter(SEPIC).

Derived Converters: Introduction, transformer models, principle of operation and analysis of fly back converter-continuous and discontinuous current mode of operation, design considerations,principle of operation and analysis of forward converter, design considerations, double ended(Two switch) forward converter, principle of operation and analysis of push-pull converter, design considerations, principle of operation and analysis of full bridge and half-bridge DC-DC converters, design considerations, current fed converters, multiple outputs.

Control of DC-DC Converter: Modeling of DC-DC converters, power supply control, control loop stability, small signal analysis, switch transfer function, filter transfer function, PWM transfer function, Type-2 error amplifier with compensation, design, PSpice simulation of feedback control, Type-3 error amplifier with compensation, design.

Resonant Converters: Introduction, resonant switch ZCS converter, principle of operation and analysis, resonant switch ZVS converter, principle of operation and analysis, series resonant inverter,series resonant DC-DC converter, parallel resonant DC-DC converter, series- parallel resonant DC-DC converter, resonant converters comparison, resonant DC link converter.

Design of inductor and transformers for SMPC.

REFERENCE BOOKS

1. Daniel W Hart, “Power Electronics”, Tata McGraw Hill, 2011.
2. Rashid M.H., “Power Electronics – Circuits Devices and Applications”, 3rd Edition, Pearson, 2011.
3. D M Mitchel, “DC-DC Switching Regulator Analysis” McGraw-Hill Ltd, 1988.
4. Umanand L and Bhatt S R, “Design of Magnetic Components for Switched Mode Power Converters”, New Age International, New Delhi, 2001
5. Ned Mohan, Tore M. Undeland, William P. Robbins, “Power Electronics Converters, Applications, and Design”, 3rd Edition, Wiley India Pvt Ltd, 2010.

M.TECH. POWER ELECTRONICS (EPE) SEMESTER - II			
POWER ELECTRONICS SYSTEM DESIGN USING ICS			
Subject Code	14EPE23	IA Marks	50
No. of Lecture Hours/Week	04	Exam Hours	03
Number of Practical Hours/week	02	Number of Tutorial Hours/week	--
Total No. of Lecture Hours	52	Exam Marks	100

Introduction: Measurement techniques for voltages, current, power, power factor in power electronic circuits, other recording and analysis of waveforms, sensing of speed.

Switching Regulator Control Circuits : Introduction, isolation techniques of switching regulator systems, PWM systems.

Commercial PWM Control ICs and their Applications: TL 494 PWM Control IC, UC 1840 Programmable off line PWM controller, UC 1524 PWM control IC, UC 1846 current mode control IC, UC 1852 resonant mode power supply controller.

Switching Power Supply Ancillary, Supervisory & Peripheral Circuits and Components: Introduction, Opto-couplers, self-biased techniques used in primary side of reference power supplies, Soft/Start in switching power supplies, current limit circuits, over voltage protection, AC line loss detection.

Phase – Locked Loops (PLL) & Applications: PLL Design using ICs, 555 timer & its applications, analog to digital converter using IC's, digital to analog converters using ICs, implementation of different gating circuits.

Programmable Logic Controllers (PLC): Basic configuration of a PLC, Programming and PLC, program modification, power converter control using PLCs.

REFERENCE BOOKS

1. G. K. Dubey, S. R. Doradla, A. Johsi, and R. M. K. Sinha, "Thyristorised Power Controllers", 2nd Edition, New Age International, 2010.
2. Chryssis "High Frequency Switching Power Supplies", 2nd Edition, MGH, 1989.
3. Unitrode application notes: http://www.smps.us/Unitrode.html

M.TECH. POWER ELECTRONICS (EPE) SEMESTER - II			
FACTS CONTROLLERS			
Subject Code	14EPE24	IA Marks	50
No. of Lecture Hours/Week	04	Exam Hours	03
Number of Practical Hours/week	02	Number of Tutorial Hours/week	--
Total No. of Lecture Hours	52	Exam Marks	100

Introduction: Basics of power transmission networks - control of power flow in AC - transmission line- flexible AC transmission system controllers – application of FACTS controllers in distribution systems.

AC Transmission Line and Reactive Power Compensation: Analysis of uncompensated AC Line - passive reactive power compensation - compensation by a series capacitor connected at the midpoint of the line - shunt compensation connected at the midpoint of the line - comparison between series and shunt capacitor - compensation by STATCOM and SSSC - some representative examples.

Static Var Compensator: Analysis of SVC - Configuration of SVC- SVC Controller – voltage regulator design - some issues - harmonics and filtering - protection aspects – modeling of SVC – applications of SVC.

Thyristor and GTO Controlled Series Capacitor: Introduction - basic concepts of controlled series compensation -operation of TCSC - analysis of TCSC- control of TCSC - modeling of TCSC for stability studies - GTO thyristor controlled series capacitor (GCSC) - mitigation of sub synchronous resonance with TCSC and GCSC - applications of TCSC.

Static Phase Shifting Transformer: General - basic principle of a PST - configurations of SPST improvement of transient stability using SPST - damping of low frequency power oscillations - applications of SPST.

Static Synchronous Compensator (STATCOM): Introduction - principle of operation of STATCOM - a simplified analysis of a three phase six pulse STATCOM - analysis of a six pulse VSC using switching functions - multi-pulse converters control of type 2 converters - control of type I Converters - multilevel voltage source converters - harmonic transfer and resonance in VSC, applications of STATCOM.

SSSC and UPFC:

SSSC-operation of SSSC and the control of power flow –modelling of SSSC in load flow and transient stability. Unified Power Flow Controller (UPFC) – Principle of operation – modes of operation – applications – modeling of UPFC for power flow studies.

Special Purpose FACTS Controllers: Interline Power Flow Controller - operation and control.

REFERENCE BOOKS

1. K.R Padiyar, “FACTS Controllers in Power Transmission and Distribution”, New Age International, 2007.
2. Narain G Hingorani and L. Gyugyi, “Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems”, Wiley India, 2011.
3. Y. H. Song and A. T. Johns, “Flexible AC Transmission System”, Institution of Engineering and Technology, 2009.
4. Mohan Mathur, R., Rajiv. K. Varma, “Thyristor – Based Facts Controllers for Electrical Transmission Systems”, IEEE press and John Wiley & Sons, Inc.

M.TECH. POWER ELECTRONICS (EPE) SEMESTER - II			
REAL TIME DIGITAL SIGNAL PROCESSING(ELECTIVE-II)			
Subject Code	14EPE251	IA Marks	50
No. of Lecture Hours/Week	04	Exam Hours	03
Number of Practical Hours/week	--	Number of Tutorial Hours/week	02
Total No. of Lecture Hours	52	Exam Marks	100

Digital Signal Processing Fundamentals: Review of DSP fundamentals ; FIR filter design by windowing; adaptive filtering techniques, Fourier analysis of signal using FFT, introduction to real time DSP and Motorola DS5630X, architecture, instruction set, addressing modes; simple 5630X program, real time digital FIR filter, real time LMS adaptive filters, real time frequency domain processing.

REFERENCE BOOKS

1.Oppenheim and Schafer, "Digital Signal Processing", Prentice Hall, 2011.
2.Philip L Se Leon, "Real Time Digital Signal Processing using the MotorolaDSP S63OXEVM",2002.
3.J G Proakis,DimitrisG Monolikis, "DigitalSignal Processing: Principles, Algorithms and Applications" Pearson Education, 4thEdition, 2012.
4. Samuel Stearns, "Digital Signal Processing with Examples in MATLAB", CRC Press, 2011.

M.TECH. POWER ELECTRONICS (EPE) SEMESTER - II			
MODELING AND ANALYSIS OF ELECTRICAL MACHINES(ELECTIVE-II)			
Subject Code	14EPE252	IA Marks	50
No. of Lecture Hours/Week	04	Exam Hours	03
Number of Practical Hours/week	--	Number of Tutorial Hours/week	02
Total No. of Lecture Hours	52	Exam Marks	100

Basic Concepts of Modeling: Basic two pole machine representation of commutator machines, 3-phase synchronous machine with and without damper bar and 3-phase induction machine, Kron's primitive machine-voltage, current and torque equations.

DC Machine Modeling: Mathematical model of separately excited DC motor-steady state and transient state analysis, sudden application of inertia load, transfer function of separately excited DC motor, mathematical model of dc series motor, shunt motor, linearization techniques for small perturbations.

Reference Frame Theory: Real time model of a two phase induction machine, transformation to obtain constant matrices, three phase to two phase transformation, power equivalence.

Dynamic Modeling of Three Phase Induction Machine: Generalized model in arbitrary frame, electromagnetic torque, deviation of commonly used induction motor models-stator reference frames model, rotor reference frames model, synchronously rotating reference frames model, equations in flux linkages, per unit model, dynamic simulation.

Small Signal Equations of the Induction Machine: Derivation of small signal equations of induction machine, space phasor model, DQ flux linkages model derivation, control principle of the induction motor.

Transformer Modeling: Introduction, single phase transformer model, three phase transformer connections, per phase analysis, normal systems, per unit normalization, per unit three phase quantities, change of base, per unit analysis of normal system, regulating transformers for voltage and phase angle control, auto transformers, transmission line and transformers.

Modeling of Synchronous Machines: Introduction, voltage equations and torque equation in machine variables, stator voltage equations in arbitrary and rotor reference frame variables, Park's equations, torque equations in substitute variables, rotor angle and angle between rotors, per unit system, analysis of steady state operation.

Dynamic Analysis of Synchronous Machines: Dynamic performance during sudden change in input torque and during a 3-phase fault at the machine terminals, approximate transient torque versus rotor angle characteristics, comparison of actual and approximate transient torque-angle characteristics during a sudden change in input torque; first swing transient stability limit, comparison of actual and approximate transient torque-angle characteristics during a 3-phase fault at the machine terminals, critical clearing time, equal area criterion, computer simulation.

REFERENCE BOOKS

1. P.S.Bimbra, "Generalized Theory of Electrical Machines", 5thEdition, Khanna Publications, 1995.
2. R. Krishnan, "Electric Motor Drives - Modeling, Analysis & Control", PHI Learning Private Ltd, 2009.
3. P.C.Krause, Oleg Wasynczuk, Scott D.Sudhoff, "Analysis of Electrical Machinery and Drive Systems", 2ndEdition, Wiley(India),2010.
4. Arthur R Bergen and Vijay Vittal, "Power System Analysis", 2nd Edition, Pearson, 2009.
5. PrabhaKundur, "Power System Stability and Control", TMH, 2010.
6. Chee-MunOng, "Dynamic Simulation of Electric Machinery using Matlab / Simulink",Prentice Hall, 1998.

M.TECH. POWER ELECTRONICS (EPE) SEMESTER - II			
ELECTRO MAGNETIC COMPATIBILITY (ELECTIVE-II)			
Subject Code	14EPE253	IA Marks	50
No. of Lecture Hours/Week	04	Exam Hours	03
Number of Practical Hours/week	--	Number of Tutorial Hours/week	02
Total No. of Lecture Hours	52	Exam Marks	100

Review of EMI Theory: Sources of EMI, noise pick up modes and reduction techniques for analog circuits.

Emissions and Reduction Techniques: Use of co-axial cables and shielding of signal lines, conducted and radiated noise emission in power electronic equipment and reduction techniques, EMI induced failure mechanisms for power electronic equipment, EMC in design of digital circuits.

Electrostatic Discharge: ESD and switching interference reduction, susceptibility aspects of power electronic and digital equipment, shielding of electronic equipment.

EMC Standards and Test Equipment.

REFERENCE BOOKS

1. Otto H. W., “Noise Reduction Techniques in Electronic Systems”, 2nd Edition, John Wiley and Sons, 1988.
2. Paul Clayton, “Introduction to Electromagnetic Compatibility”, 2nd Edition, Wiley Interscience, 2006.
3. William B. Greason, “Electrostatic Damage in Electronics: Devices and Systems”, John Wiley and Sons, 1986.
4. Joseph Di Giacomo, “Digital Bus Hand Book”, McGraw Hill Publishing Company, 1990.
5. White, R. J., “Handbook Series of Electromagnetic Interference and Compatibility”, Don White consultants Inc. 1981.

M.TECH. POWER ELECTRONICS (EPE) SEMESTER - II			
POWER ELECTRONICSLABORATORY - II			
Subject Code	14EPE26	IA Marks	25
No. of Lecture Hours/Week	--	Exam Hours	03
Number of Practical Hours/week	03	Number of Tutorial Hours/week	--
Total No. of Practical Hours	--	Exam Marks	50

1.Study and performance analysis of single phase fully controlled converter fed separately excited DC Motor for continuous current mode.
2.Study and performance analysis of single phase fully controlled converter fed separatelyexcited DC Motor for discontinuous current mode.
3.Study and performance analysis of three phase fully controlled converter fed separatelyexcited DC Motor for continuous current mode.
4.Study and performance analysis of three phase fully controlled converter fed separately excited DC Motor for discontinuous current mode.
5.Performance analysis of a practical chopper fed DC Drives system for class-A and class-C commutation and analysis of wave forms in continuous mode.
6. Simulation study of buck, boost and buck- boost converter (basic topologies) and analysisof wave forms for continuous current mode (CCM).
7. Simulation study of buck, boost and buck-boost converter (basic topologies) and analysis of wave forms for discontinuous current mode (DCM).
8. Simulation study of forward converter and fly back converter and performance analysis of various wave forms.
9. Resonant converter simulation study and analysis
10.Closed loop operation of a buck and boost converter.

M.TECH. POWER ELECTRONICS (EPE) SEMESTER - II			
SEMINAR			
Subject Code	14EPE27	IA Marks	25
No. of Lecture Hours/Week	--	Exam Hours	--
Number of contact Hours/week	03	Number of Tutorial Hours/week	--
Total No. of Hours	--	Exam Marks	--

M.TECH. POWER ELECTRONICS (EPE) SEMESTER - III					
INTERNSHIP					
Subject Code	14EPE31	IA Marks Seminar/Presentation			25
Duration	16 weeks	Exam Marks	14EPE32	Report on Internship	75
			14EPE33	Internship Evaluation and Viva-voce	50

M.TECH. POWER ELECTRONICS (EPE) SEMESTER - IV			
HVDC POWER TRANSMISSION			
Subject Code	14EPE41	IA Marks	50
No. of Lecture Hours/Week	04	Exam Hours	03
Number of Practical Hours/week	--	Number of Tutorial Hours/week	--
Total No. of Lecture Hours	52	Exam Marks	100

DC Power Transmission Technology: Introduction, comparison with AC transmission, application of DC transmission, description of DC transmission system, Planning of HVDC transmission, modern trends in DC transmission, operating problems.

HVDC Converters: Introduction to Line commutated converter, choice of converter configuration for any pulse number, analysis of 6 and 12 pulse Graetz bridge converter without overlap, effect of smoothing reactor. Two and Three level voltage source converters, Pulse Width Modulation. Analysis of converter in two and three, and three and four valve conduction modes, LCC bridge characteristics, Twelve pulse converter, detailed analysis of converters. Analysis of Capacitor Commutated and voltage source converters.

Control of Converters and HVDC link: DC link control principles, converter control characteristics, firing angle control, current and extinction angle control, Starting and stopping of Dc link, Power control, Frequency control, Reactive power control, Tap changer control, Emergency control and Telecommunication requirements. Control of voltage source converter.

Converter Faults and Protection: Converter faults, protection against over currents, over voltages in converter station, surge arrestor, protection against over voltages. Protection against faults in voltage source converter.

Smoothing Reactor and DC line: Smoothing reactors, Effects of corona loss, DC line insulators, Transient over voltages in DC line, Protection in dc line, Detection and protection of faults, DC breaker

Reactive Power Control: Reactive power control in steady state and transient state, sources of reactive power, SVC and STATCOM.

Harmonics and Filters: Introduction, Generation of harmonics, design of AC and DC filters.

Power Flow Analysis in AC/DC Systems: Introduction, dc system model, solution procedure, inclusion of constraints, case study, on line power flow analysis for security control, power flow analysis under dynamic conditions, power flow with VSC based HVDC system.

Stability Analysis and Power Modulation: Introduction to stability concepts, power modulation, practical considerations in the application of modulation controllers, voltage stability, analysis of voltage stability in asynchronous AC/DC system.

Multi Terminal DC Systems: Introduction, applications, types, control and protection.

REFERENCE BOOKS

1. K. R. Padiyar, “HVDC Power Transmission Systems”, New Age International, 2012.
2. E.W.Kimbark “Direct Current Transmission”, Vol.1, Wiley Inter-Science, London, 2006.
3. Arrilaga, “High Voltage Direct Current Transmission”, The Institute of Engineering and Technology, 2ndEdition, 2007.
4. S Kamakshaiah and V Kamaraju, “HVDC Transmission”, TMH, 2011.

M.TECH. POWER ELECTRONICS (EPE) SEMESTER - IV			
POWER QUALITY ENHANCEMENT USING CUSTOM POWER DEVICES MITIGATION(ELECTIVE- III)			
Subject Code	14EPE421	IA Marks	50
No. of Lecture Hours/Week	04	Exam Hours	03
Number of Practical Hours/week	--	Number of Tutorial Hours/week	--
Total No. of Lecture Hours	52	Exam Marks	100

Introduction and Characterization of Electric Power Quality: Electric Power Quality, Power Electronic applications in Power Transmission Systems, Power Electronic applications in Power Distribution Systems. Power Quality terms and Definitions, Power Quality Problems.
Analysis and Conventional Mitigation Methods: Analysis of Power Outages, Analysis of Unbalance , Analysis of Distortion, Analysis of Voltage Sag, Analysis of Voltage Flicker, Reduced Duration and Customer impact of Outages, Classical Load Balancing Problem, Harmonic Reduction, Voltage Sag or Dip Reduction.
Custom Power Devices: Introduction, Utility-Customer Interface, Custom Power Devices, Custom Power Park, Status of Application of CP Devices, Closed-Loop Switching Control, Second and higher order Systems.
Solid State Limiting, Breaking and Transferring Devices: Solid State Current Limiter, Solid State Breaker, Issues in Limiting and Switching operations, Solid State Transfer Switch, Sag/Swell Detection Algorithms.
Load Compensation using DSTATCOM: Compensating Single-Phase Loads, Ideal Three-Phase Shunt Compensator Structure, Generating Reference Currents Using Instantaneous PQ Theory, Generating reference currents using instantaneous Symmetrical Components, General Algorithm for generating reference currents, Generating Reference currents when the Source is Unbalanced.
Realization and Control of DSTATCOM: DSTATCOM Structure, Control of
DSTATCOM Connected to a Stiff Source, DSTATCOM Connected to weak Supply Point, DSTATCOM Current Control through Phasors, DSTATCOM in Voltage Control Mode.
Series Compensation of Power Distribution System: Rectifier Supported DVR, DC Capacitor Supported DVR, DVR Structure, Voltage Restoration, Series Active Filter.
Unified Power Quality Conditioner: UPQC Configurations, Right-Shunt UPQC Characteristics, Left-Shunt UPQC Characteristics, Structure and Control of Right-Shunt UPQC, Structure and Control of Left-Shunt UPQC.

REFERRENCE BOOKS

1. Arindam Ghosh et.al, Power Quality Enhancement Using Custom Power Devices,Kluwer Academic Publishers,2002.
2. Math H J Bollen, "Understanding Power Quality Problems; Voltage Sags and Interruptions", Wiley India, 2011.
3. Roger C Dugan, et.al, "Electrical Power Systems Quality", 3rd Edition, TMH, 2012.
4. G T Heydt, "Electric Power Quality", Stars in Circle Publications, 1991.
5. Ewald F Fuchs, et.el, "Power Quality in Power System and Electrical Machines", Academic Press, Elsevier, 2009.
6. C. Shankaran "Power Quality", CRC Press, 2013.

M.TECH. POWER ELECTRONICS (EPE) SEMESTER - IV			
PWM CONVERTERS AND APPLICATIONS(ELECTIVE- III)			
Subject Code	14EPE422	IA Marks	50
No. of Lecture Hours/Week	04	Exam Hours	03
Number of Practical Hours/week	--	Number of Tutorial Hours/week	--
Total No. of Lecture Hours	52	Exam Marks	100

AC/DC and DC/AC Power Conversion: Overview of applications of voltage source converters.

PWM Techniques: Pulse modulation techniques for I – phase bridges, bus clamping PWM, space vector based PWM, advanced PWM techniques.

Loss Calculations: Practical devices in converters, calculation of switching and conduction losses, compensation for dead time and DC voltage regulation.

Modeling: Dynamic model of PWM converters; constant V/F induction motor drives; estimation of current ripple and torque ripple in inverter fed drives.

Converters with Compensation: Line-side converters with power factor compensation, reactive power compensation, harmonic current compensation.

REFERENCE BOOKS

1. Mohan, Undeland and Robbins, “Power Electronics: Converter, Applications and Design”, Wiley India, 2011.
2. Erickson RW, “Fundamentals of Power Electronics”, Chapman Hall, 1997.
3. Joseph Vithyathil, “Power Electronics- Principles and Applications”, TMH, 2011.

M.TECH. POWER ELECTRONICS (EPE) SEMESTER - IV			
DSP APPLICATIONS TO DRIVES(ELECTIVE- III)			
Subject Code	14EPE423	IA Marks	50
No. of Lecture Hours/Week	04	Exam Hours	03
Number of Practical Hours/week	--	Number of Tutorial Hours/week	--
Total No. of Lecture Hours	52	Exam Marks	100

Introduction: To the TMS320LF2407 DSP Controller, C2xx DSP CPU architecture and instruction set. General Purpose Input/output (GPIO) functionality interrupts on the TMS320LF2407, Analog-to-Digital Converter (ADC), event managers (EVA, EVB).
DSP-Based Applications: Of DC-DC buck-boost converters, DSP based control of stepper motors, DSP-Based control of permanent magnet brushless DC machines, Park and Clarke's transformations.
Space Vector Pulse Width Modulation, DSP-based control of permanent magnet synchronous machines.
DSP-based vector control of induction motors.

REFERENCE BOOKS

1. Hamid Toliyat and Steven Campbell, “DSP-Based Electromechanical Motion Control”, CRC Press, 2011.
2. P.C.Krause, Oleg Wasynczuk, Scott D.Sudhoff, “Analysis of Electrical Machinery and Drive Systems”, 2^{nd} Edition, Wiley India,2010
3. Chee-Mun Ong, “Dynamic Simulation of Electric Machinery using Matlab / Simulink”, Prentice Hall,1998.

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