M.TECH. POWER ELECTRONICS (EPE)
### I Semester

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Name of the Subject</th>
<th>Teaching hours/week</th>
<th>Duration of Exam in Hours</th>
<th>Marks for</th>
<th>Total Marks</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>12MAT11</td>
<td>Applied Mathematics</td>
<td>4</td>
<td>3</td>
<td>50</td>
<td>150</td>
<td>4</td>
</tr>
<tr>
<td>14 EPE 12</td>
<td>Power Semiconductor Devices</td>
<td>4</td>
<td>3</td>
<td>50</td>
<td>150</td>
<td>4</td>
</tr>
<tr>
<td>14 EPE 13</td>
<td>Modeling and Simulation of Power Electronic Systems</td>
<td>4</td>
<td>3</td>
<td>50</td>
<td>150</td>
<td>4</td>
</tr>
<tr>
<td>14 EPE 14</td>
<td>Solid State Power Controllers</td>
<td>4</td>
<td>3</td>
<td>50</td>
<td>150</td>
<td>4</td>
</tr>
<tr>
<td>14 EPE 15X</td>
<td>Elective-I</td>
<td>4</td>
<td>3</td>
<td>50</td>
<td>150</td>
<td>4</td>
</tr>
<tr>
<td>14 EPE 16</td>
<td>Power Electronics Laboratory - I</td>
<td>--</td>
<td>3</td>
<td>25</td>
<td>75</td>
<td>2</td>
</tr>
<tr>
<td>14 EPE 17</td>
<td>Seminar</td>
<td>--</td>
<td>--</td>
<td>25</td>
<td>25</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>20</strong></td>
<td><strong>16</strong></td>
<td><strong>300</strong></td>
<td><strong>550</strong></td>
<td><strong>850</strong></td>
</tr>
</tbody>
</table>

**Elective – I**

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Name of the Subject</th>
</tr>
</thead>
<tbody>
<tr>
<td>14EPE151</td>
<td>Embedded System Design</td>
</tr>
<tr>
<td>14EPE152</td>
<td>Soft Computing</td>
</tr>
<tr>
<td>14EPE153</td>
<td>Advanced Control Systems</td>
</tr>
<tr>
<td>Subject Code</td>
<td>Name of the Subject</td>
</tr>
<tr>
<td>--------------</td>
<td>----------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>14EPE21</td>
<td>AC and DC Drives</td>
</tr>
<tr>
<td>14 EPE 22</td>
<td>Switched Mode Power Conversion</td>
</tr>
<tr>
<td>14 EPE 23</td>
<td>Power Electronics System Design using ICs</td>
</tr>
<tr>
<td>14 EPE24</td>
<td>FACTS Controllers</td>
</tr>
<tr>
<td>14 EPE 25X</td>
<td>Elective-II</td>
</tr>
<tr>
<td>14 EPE 26</td>
<td>Power Electronics Laboratory - II</td>
</tr>
<tr>
<td>14 EPE 27</td>
<td>Seminar</td>
</tr>
<tr>
<td></td>
<td>**Project Phase-I (6 week Duration)</td>
</tr>
</tbody>
</table>

** Total       | 20           | 16           | 18                         | 300         | 550         | 850     | 23      |

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

Elective – II

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Name of the Subject</th>
</tr>
</thead>
<tbody>
<tr>
<td>14EPE251</td>
<td>Real Time Digital Signal Processing</td>
</tr>
<tr>
<td>14EPE252</td>
<td>Modeling and Analysis of Electrical Machines</td>
</tr>
<tr>
<td>14EPE253</td>
<td>Electro Magnetic Compatibility</td>
</tr>
</tbody>
</table>
### III Semester: INTERNSHIP

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Subject</th>
<th>No. of Hrs/Week</th>
<th>Duration of Exam in Hours</th>
<th>Marks for Total</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lecture</td>
<td>Practical/Field Work</td>
<td>IA</td>
<td>Exam</td>
</tr>
<tr>
<td>14EPE31</td>
<td>Seminar/Presentation on Internship (After 8 weeks from the date of commencement)</td>
<td>--</td>
<td>--</td>
<td>25</td>
<td>--</td>
</tr>
<tr>
<td>14EPE32</td>
<td>Report on Internship</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>75</td>
</tr>
<tr>
<td>14EPE33</td>
<td>Evaluation and Viva-Voce</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>50</td>
</tr>
</tbody>
</table>

**Total**

| -- | -- | -- | 25 | 125 | 150 | 20 |

**Total Marks**: 150

**Credits**: 20
<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Subject</th>
<th>Lecture</th>
<th>Field Work / Assignment / Tutorials</th>
<th>Duration of Exam in Hours</th>
<th>IA</th>
<th>Exam</th>
<th>Total Marks</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>14EPE41</td>
<td>HVDC power Transmission</td>
<td>4</td>
<td>--</td>
<td>3</td>
<td>50</td>
<td>100</td>
<td>150</td>
<td>4</td>
</tr>
<tr>
<td>14EPE42X</td>
<td>Elective-III</td>
<td>4</td>
<td>--</td>
<td>3</td>
<td>50</td>
<td>100</td>
<td>150</td>
<td>4</td>
</tr>
<tr>
<td>14EPE43</td>
<td>Evaluation of Project Phase – II</td>
<td>--</td>
<td>--</td>
<td>25</td>
<td>--</td>
<td>--</td>
<td>25</td>
<td>1</td>
</tr>
<tr>
<td>14EPE44</td>
<td>Evaluation of Project work – III</td>
<td>--</td>
<td>--</td>
<td>25</td>
<td>--</td>
<td>--</td>
<td>25</td>
<td>1</td>
</tr>
<tr>
<td>14EPE45</td>
<td>Evaluation of Project Work and Viva-voce</td>
<td>--</td>
<td>--</td>
<td>3</td>
<td>--</td>
<td>100+100</td>
<td>200</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>8</td>
<td>--</td>
<td>09</td>
<td>50</td>
<td>400</td>
<td>550</td>
<td>28</td>
</tr>
</tbody>
</table>

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

**Elective - III**

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Name of the Subject</th>
</tr>
</thead>
<tbody>
<tr>
<td>14EPE421</td>
<td>Power Quality Enhancement using Custom Power Devices</td>
</tr>
<tr>
<td>14EPE422</td>
<td>PWM Converters and Applications</td>
</tr>
<tr>
<td>14EPE423</td>
<td>DSP Applications to Drives</td>
</tr>
</tbody>
</table>
Note:

1) Project Phase – I: 6 weeks duration shall be carried out between II and III Semesters. Candidates in consultation with the guides shall carry out 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.


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).
### 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
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 re-applied 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 requirements, 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
### M.TECH. POWER ELECTRONICS (EPE)  
**SEMESTER - 1**  
**MODELING AND SIMULATION OF POWER ELECTRONIC SYSTEMS**

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>IA Marks</th>
<th>No. of Lecture Hours/Week</th>
<th>Exam Hours</th>
<th>Number of Practical Hours/week</th>
<th>Number of Tutorial Hours/week</th>
<th>Total No. of Lecture Hours</th>
<th>Exam Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>14EPE13</td>
<td>50</td>
<td>04</td>
<td>03</td>
<td>02</td>
<td>--</td>
<td>52</td>
<td>100</td>
</tr>
</tbody>
</table>

**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**

M.TECH. POWER ELECTRONICS (EPE)
SEMESTER - I
SOLID STATE POWER CONTROLLERS

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>IA Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>14EPE14</td>
<td>50</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No. of Lecture Hours/Week</th>
<th>Exam Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>04</td>
<td>03</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of Practical Hours/week</th>
<th>Number of Tutorial Hours/week</th>
</tr>
</thead>
<tbody>
<tr>
<td>02</td>
<td>--</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total No. of Lecture Hours</th>
<th>Exam Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>52</td>
<td>100</td>
</tr>
</tbody>
</table>

**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**

**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**

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.


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

**M.TECH. POWER ELECTRONICS (EPE)**  
**SEMESTER - 1**  
**ADVANCED CONTROL SYSTEMS (ELECTIVE-I)**

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>IA Marks</th>
<th>No. of Lecture Hours/Week</th>
<th>Exam Hours</th>
<th>Number of Practical Hours/week</th>
<th>Number of Tutorial Hours/week</th>
</tr>
</thead>
<tbody>
<tr>
<td>14EPE153</td>
<td>50</td>
<td>04</td>
<td>03</td>
<td>--</td>
<td>02</td>
</tr>
</tbody>
</table>

**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 observ (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. 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
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.

**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**

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

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.


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

**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 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:**

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

**REFERENCE BOOKS**

**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**

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.


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.


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
M.TECH. POWER ELECTRONICS (EPE)
SEMESTER - II
ELECTRO MAGNETIC COMPATIBILITY (ELECTIVE-II)

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>IA Marks</th>
<th>No. of Lecture Hours/Week</th>
<th>Exam Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>14EPE253</td>
<td>50</td>
<td>04</td>
<td>03</td>
</tr>
<tr>
<td>Number of Practical Hours/week</td>
<td>02</td>
<td>Number of Tutorial Hours/week</td>
<td></td>
</tr>
<tr>
<td>Total No. of Lecture Hours</td>
<td>52</td>
<td>Exam Marks</td>
<td>100</td>
</tr>
</tbody>
</table>

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. 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 separately excited DC Motor for discontinuous 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 analysis of 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.
<table>
<thead>
<tr>
<th>SEMINAR</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject Code</td>
<td>14EPE27</td>
</tr>
<tr>
<td>No. of Lecture Hours/Week</td>
<td>--</td>
</tr>
<tr>
<td>Number of contact Hours/week</td>
<td>03</td>
</tr>
<tr>
<td>Total No. of Hours</td>
<td>--</td>
</tr>
<tr>
<td>Subject Code</td>
<td>IA Marks Seminar/Presentation</td>
</tr>
<tr>
<td>--------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>14EPE31</td>
<td>25</td>
</tr>
<tr>
<td>Duration</td>
<td>16 weeks</td>
</tr>
</tbody>
</table>
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 arrester, 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


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.

REFERENCE BOOKS

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

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