M.TECH. POWER ELECTRONICS (EPE)  
1 SEMESTER

12MAT11 APPLIED MATHEMATICS

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**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.

Thyristsors: 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—V-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 its 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**


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 modeling 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.

REFERENCES

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.


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

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**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**

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)**

**II SEMESTER**

**AC-DC DRIVES**

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| Total No. of Lecture Hours| 52 | Exam Marks | 100 |


**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, classification, basic resonant circuit concepts, resonant switch converters, zero voltage switching, clamped voltage topologies, resonant DC link converters, and high frequency link integral half cycle converters.

**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

DC Power Transmission Technology: General aspects of DC transmission, comparison with AC transmission, application, advantages and disadvantages of DC transmission, description of DC transmission systems, modern trends in DC transmission.

Analysis of HVDC Converters: Effects of source inductance, equivalent circuits and characteristics of 6 pulse and 12 pulse converters.

Control and Protection Methods: DC link control principles, converter control characteristics, firing angle control, fault development and protection schemes, DC reactor and its design consideration, DC breakers.

Harmonics: Generation of harmonics, design of AC filters and DC filters, reactive power control – discussion on control strategies under steady state and transient state and sources of reactive power in HVDC systems, static VAR systems.

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


Power Flow Analysis in AC/DC Systems: Modeling of DC links, solution of DC load flow, per unit system for DC quantities, solution of AC-DC power flow.

REFERENCE BOOKS

12EPE251 REAL-TIME DIGITAL SIGNAL PROCESSING

Subject Code: 12EPE251
IA Marks: 50

No. of Lecture Hours/Week: 04
Exam Hours: 03

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

12EPE252  ADVANCED CONTROL SYSTEMS

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**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 observers (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**

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 Equipments.

REFERENCE BOOKS

Introduction: Introduction to smart grid, electricity network, local energy networks, electric transportation, low carbon central generation, fundamental problems of electrical power systems, power flow control, distributed generation and energy storage, attributes of the smart grid, alternate views of a smart grid.

Power Control and Quality Problems: Introduction, general problems and solutions of power control, power quality and EMC, power quality issues, monitoring, legal and organizational regulations, mitigation methods, and EMC related phenomena in smart system, EMC cases in distributed power system.

High frequency AC Power Distribution Platform: Introduction, high frequency in space applications, telecommunications, computer and commercial electronics systems, automotive and motor drives, micro grids.

Integration of Distributed Generation with Power System: Distributed generation past and future, interconnection with a hosting grid, integration and interconnection concerns, power injection principle, injection using static compensators and advanced static devices, distributed generation contribution to power quality problems and current challenges.

Active Power Controllers: Dynamic static synchronous controllers, D – STATCOM, Dynamic static synchronous series controllers, dynamic voltage restorer, AC/AC voltage regulators.
Energy Storage Systems: Introduction, structure of power storage devices, pumped – storage hydroelectricity, compressed air energy storage system, flywheels, battery storage, hydrogen storage, super conducting magnet energy storage, super capacitors, applications of energy storage devices.

REFERENCE BOOKS

ELECTIVES - III

12EPE321  CMOS VLSI DESIGN

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**Review of MOS Circuits:** MOS and CMOS static plots, switches, comparison between CMOS and BI - CMOS.

**MESFETS:** MESFET and MOSFET operations, quantitative description of MESFETS.

**MIS Structures and MOSFETS:** MIS systems in equilibrium, under bias, small signal operation of MESFETS and MOSFETS.

**Short Channel Effects and Challenges to CMOS:** Short channel effects, scaling theory, processing challenges to further CMOS miniaturization.

**Beyond CMOS:** Evolutionary advances beyond CMOS, carbon nano tubes, conventional vs. tactile computing, computing, molecular and biological computing, mole electronics-molecular diode and diode- diode logic ,effect tolerant computing.

**Super Buffers, Bi-CMOS and Steering Logic:** Introduction, RC delay lines, super buffers- an NMOS super buffer, tri-state super buffer and pad drivers, CMOS super buffers, dynamic ratio less inverters, large capacitive loads, pass logic, designing of transistor logic, general functional blocks - NMOS and CMOS functional blocks.

**Special Cirit Layouts and Technology Mapping:** Introduction, Talley circuits, NAND-NAND, NOR- NOR, and AOI Logic, NMOS, CMOS multiplexers, barrel shifter, wire routing and module lay out.
**System Design:** CMOS design methods, structured design methods, strategies encompassing hierarchy, regularity, modularity & locality, CMOS Chip design options, programmable logic, programmable inter connect, programmable structure, gate arrays standard cell approach, full custom design.

**REFERENCE BOOKS**

Review: Linear Regulators, control of inverter and converter with special C modules, transformer design by calculation and by monographs.

Switching Type Power Supplies: Theory, noise consideration, switching of AC and DC voltages, voltage references and comparators – switching type regulator.

SMPS- Characteristics – steady state analysis control.

Methods: Design of feedback compression.

UPS: Necessity, types, typical layouts of UPS, stand alone high quality electronics power supplies.

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

ELECTIVE-IV

12EPE331 POWER QUALITY ISSUES AND MITIGATION

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**Introduction:** Introduction to power quality, overview of power quality phenomena, power quality and EMC standard.

**Long Interruptions and Reliability Evaluation:** Introduction, observation of system performance, standards and regulations, overview of reliability evaluation, reliability evaluation techniques, cost of interruptions, comparison of observation and reliability evaluation, examples.

**Short Interruptions:** Introduction, terminology, origin of short interruptions, monitoring of short interruptions, influence on equipment, single phase tripping, stochastic prediction of short interruptions.

**Voltage Sags - Characterization:** Introduction, voltage sag magnitude, voltage sag duration, three phase unbalance, phase angle jumps, magnitude and phase angle jumps for three phase unbalanced sags, other characteristic of voltage sags, load influence on voltage sags, sag due starting of induction motors.

**Voltage Sags – Equipment Behavior:** Introduction, computers and consumer electronics, adjustable speed AC drives, adjustable speed DC drives, other sensitive load.

**Voltage Sags – Stochastic Assessment:** Compatibility between equipment and supply, voltage sag coordination chart, power quality monitoring, method of fault positions, method of critical distances.

**Mitigation of Interruptions and Voltage Sags:** Overview of mitigation methods, power system design – redundancy through switching and parallel operation, system equipment interface.
REFERENCE BOOKS

**12EPE332 FACTS CONTROLLERS**

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**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 - multipulse converters control of type 2 converters - control of type I Converters - multilevel voltage source converters - harmonic transfer and resonance in VSC, applications of STATCOM.
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