COMMON SYLLABUS
for
M Tech
On
Power Electronics and Drives
### 1st Semester

#### Theory:

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Page 2 of 18
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**TOTAL OF SEMESTER:**

| Credits | 28 | 22 |

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**Total Credits:** $26 + 30 + 22 + 22 = 100$
**FIRST SEMESTER:**

### A. THEORY

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<td>(c) Microcontroller Based System Design</td>
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<td>(d) Energy Management &amp; Audit</td>
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**TOTAL OF THEORY** 500

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**TOTAL OF PRACTICAL / SESSIONAL** 300

**TOTAL OF SEMESTER** 800

**SECOND SEMESTER:**

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**TOTAL OF THEORY** 500

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**TOTAL OF PRACTICAL / SESSIONAL** 300

**TOTAL OF SEMESTER** 800
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**TOTAL OF THEORY** 200

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**TOTAL OF SESSIONAL** 200

**TOTAL OF SEMESTER** 400

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**TOTAL OF SESSIONAL** 500

**TOTAL OF SEMESTER** 500
Advanced Engineering Mathematics

EAM 101
Contact: 3L+1T
Credits: 04

Complex Variables:
Review of complex variables, Conformal mapping & transformations, Function of complex variables, Pole and singularity, Integration with respect to complex argument, Residues and basic theorems on residues.

Numerical Analysis:
Introduction, Interpolation formulae, Difference equation, Roots of equations, Solution of simultaneous linear and non-linear equations, Solution techniques for ODE and PDE, Introduction to stability, Matrix eigen value and eigen vector problems.

Optimization Technique:
Calculus of several variables, Implicit function theorem, Nature of singular points, Necessary and sufficient conditions for optimization, Elements of calculus variation, Constrained Optimization, Lagrange multipliers, Gradient method, Dynamic programming.

Linear Algebra:
Vector space, Linear dependence of vectors, basis, linear transformations, inner product space, rank and inverse of a matrix, solution of algebraic equations, consistency conditions, Eigen values and eigen vectors, Hermitian and Skew Hermitian matrices.

Books:
5. S.S.Rao., Optimisation theory and application, Wiely Eastern limited
6. Hoffman & Kunze, R., Linear Algebra, PHI

POWER ELECTRONICS – I

PEM 101
Contact: 3L+1T
Credits: 04

Switch Realization: Survey of power semiconductor devices, Power diode, SCR, GTO, LASCR, RCT, SITH, BJT, MOSFET, IGBT etc., Switching losses, driver circuits, protection, cooling, application.


DC- DC Converters: principle of operation of buck, boost, buck-boost, Cuk, fly back, forward, push-pull, half bridge, full bridge Converters with continuous and discontinuous operation, Input & output filter design, multi-output boost converters, diode rectifier based boost converters. State space analysis of regulators.

**Converter Dynamics / simulations:** Feed back control for converters: regulation and control problem, control principles, model for feedback, P and PI control. Non linear dynamic modeling , Control and analysis of choppers, voltage mode and current mode control. Simulation: process, mechanics, techniques, PSPICE simulator.

EMI and Power Quality Problems. Power conditioning. PLL / Micro computer based converters and choppers

**Texts:**
5. P. T. Krein, “Elements of Power Electronics”, OUP

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**Electrical Machines Analysis**

**PEM 102**  
**Contact:** 3L+1T  
**CREDITS:** 04

**Basic Principles for Analysis:** Introduction, Magnetically coupled circuit, Electromechanical Energy Conversion, Machine windings and Air gap MMF, Winding inductances and voltage equations.


**Induction Machines:** Introduction, Voltage and torque equations in machine variables, Equations of Transformation for rotor circuit, Voltage and Torque Equations in Arbitrary reference Frame Variables, Analysis of steady state operation, Free acceleration characteristics viewed from other reference frame, Dynamic performance during sudden change in load torque, Linearized model, Eigen values and small displacement stability, Reduced order equations and dynamics.

**Synchronous Machines:** Introduction, Voltage and torque equations in machine variables, Voltage and Torque Equations in Arbitrary reference Frame Variables, Voltage and Torque Equations in Rotor Reference Frame Variables, Torque Equations in Substitute variables, Analysis of steady state operation, Dynamic Performance during a sudden change in Input torque, Linearized model, Eigen values and small displacement stability, Reduced order equations and dynamics.

**DC Machines:** Introduction, Voltage and torque equations in machine variables, Basic types of the machine, Dynamic characteristics of permanent magnet and DC Shunt Motors, Time domain Block Diagrams and state equations, Solution of Dynamic equation by Laplace Transformation.

**Texts:**
2. Ong Moon Lee  “Dynamics Simulation of Electrical Machines” Prentice Hall
Advanced Control Systems

PEM 103
Contact: 3L+1T
Credits: 04

Review of Modeling and Analysis of LTI Systems:
Modeling of physical Systems. Design specifications and performance indices, Motion control systems,
Transportation lags. Approximation of time-delay functions., Sensitivity of control systems to parameter variations. Effects of
disturbance of signals. Disturbance rejection.

Analysis in state-space:
A perspective on state-space design. State variables. State models for physical systems. SISO and MIMO systems. Solution of
state equations. Transfer function. Eigenvalues and eigenvectors. Jacobian linearization technique. State transformations and

Introduction to Discrete-time Systems:
Basic elements of discrete-time control system. Z-transform and properties. Inverse Z-transform. Difference equation and its
decomposition of Z-transfer functions.

Feedback control design:
Continuous control design. Proportional, derivative and integral control action. PID controller tuning rules. Ziegler-Nichols
Control law design for full state feedback by pole placement. Full order observer system. Observer based state feedback.
Separation principal.

Non linear system:
Classification and types of non-linearity. Phenomena peculiar to non-linear systems. Methods of analysis. Linearization based
on Taylor’s series expansion. Jacobian Linearization.
Describing function of typical non-linearities. Stability analysis by DF method. Introduction to DIDF. Popov’s circle criterion.
Stability analysis by Lyapunov’s indirect and direct methods, Lyapunov’s theorem.

Reference Books:
1. Ogata, K – Modern Control Engineering, PHI Learning
3. Roy Choudhury, D – Modern Control Engineering, Prentice Hall
7. Vidyasagar- Nonlinear system analysis, Prentice-Hall.
9. Gopal. M, Digital Control and State Variable Methods, TMH.

Solid State Power Controllers

P 104(a)
Contact: 4L
Credits: 04

stability considerations of a transmission interconnection – relative importance of controllable parameter – opportunities for
FACTS – possible benefits for FACTS Technology – FACTS Controllers – Types, brief description and definitions

STATIC VAR COMPENSATION: Need for compensation – introduction to shunt and series compensation – objectives of
shunt and series compensation – configuration and operating characteristics – Thyristor Controlled Reactor (TCR) – Thyristor
Switched Capacitor (TSC) – Fixed Capacitor - Thyristor Controlled Reactor (FC – TCR) – Comparison of TCR, TSC and FC – TCR

SERIES COMPENSATORS: Commutation in DC motors, difference between mechanical and electronic Commutators, Hall sensors, Optical sensors, Multiphase Brushless motor, Square – Wave permanent magnet brushless motor drives, torque and EMF equation, torque – speed characteristics of Permanent Magnet Brush less DC Motors – controllers PM DC Motor

STATIC VOLTAGE AND PHASE ANGLE REGULATORS: Objectives of voltage and phase angle regulators – approaches to Thyristor – Controlled Voltage and Phase Angle Regulator

EMERGING FACTS CONTROLLERS: Construction and principle of operation of Linear Induction Motor - Universal Motor - Hybrid Motor – Linear Synchronous motor – Applications


Texts/References

Digital Signal Processing

PEM 104(b)
Contact: 4L
Credit: 4


Digital Filter: Definition and anatomy of a digital filter, Frequency domain description of signals and systems, Typical application of digital filters, Replacing analog filters with digital filters, Filter categories: recursive and non-recursive

Digital Filter Structures: The direct form I and II structures, Cascade combination of second order sections, Parallel combination of second order sections, Linear- phase FIR filter structures, Frequency sampling structure for the FIR filter

Effect of Word Length: Round off error, Truncation error, Quantization error, Limit cycle

Introduction to DSP Hardware: Application of DSP in control system and instrumentation

Suggested Readings:
1. S. K. Mitra, Digital Signal Processing,
Micro controller based system design

PEM 104(c)
Contact: 4L
Credits: 04

Introduction – embedded systems and their characteristics, review of micro – processors, MPU design options, Instruction sets – CISC and RISC – instruction pipelining, the microcontroller – its applications and environment.


Introduction, PIC microcontrollers PIC 16 C6x/7x, architecture, register file structure and addressing modes, Instruction set, simple programs

Peripheral functions of PIC 16C6x/7x - Interrupts - Interrupts constraints – Interrupt servicing – Critical regions – External Interrupts – Use of Timers in interrupt Handling – Compare and capture mode – PWM outputs

I/O port expansion – Synchronous serial port module – State machines and key switches LCD display – I2C bus operations and subroutine – serial EEPROM

Analog to Digital converter: Characteristics and use

UART : Initialization – Data Handling circuitry and USE

Special Features of PIC – Reset Alternatives Low power operation – Serial programming – parallel slave port

REFERENCE BOOKS :

Energy Management and Audit

PEM 104(d)
Contact: 4L
Credits: 04


Energy Action Planning: Role, motivation, training, information systems.

Energy monitor of Electrical system: Power supply, Electricity billing, Electrical load management and maximum demand control, Power factor improvement and its benefit, Selection and location of capacitors, Performance assessment of PF capacitors, Distribution and transformer losses.


Lighting System: Light source, Choice of lighting, Luminance requirements, and Energy conservation avenues.


Books:
1. Albert : Plant Engineers & Managers Guide to Energy Conservation

Electrical Engineering Laboratory-I

PEM 191
Contact: 2P
Credits: 02
Hardware experiments / Software experiments / hardware simulation / software simulation on Electrical Engineering.

Electrical Engineering Laboratory-II

PEM 192
Contact: 3P
Credits: 02
Hardware experiments / Software experiments / hardware simulation / software simulation on Electrical Engineering.

Seminar-I

EMP 193
Contact: 3P
Credits: 02
Assigned Seminar on recent topics

Power Electronics - II

PEM 201
Contact: 3L+1T
Credits: 04

Inverters: Single and three phase bridge inverters with R, RL and RLE loads, Voltage control, Harmonic reduction, square wave inverters, PWM inverters, modulation techniques, SPWM, Selective Harmonic Elimination PWM and delta modulation, blanking time, harmonic spectrum and comparison among different PWM techniques. Boost inverter. Current source inverters, Inverter Circuit Design.

Resonant Pulse Converters: Series and parallel resonant inverters - zero current and Zero voltage switching resonant converters, frequency response. Two quadrant zero voltage switching resonant converters, Resonant dc link inverters, design and analysis, soft switching, load dependent problem.

Multi level inverters: types, operations, features.

Cycloconverters: Single phase and three phase cycloconverters with R, RL and RLE loads – Voltage control, Harmonic analysis, operation waveforms designs.

AC voltage controllers: Single phase and three phase ac voltage controllers with R, RL and RLE loads, Voltage control, Harmonic analysis, operation waveforms PWM, Matrix converter, design.

Page 18


Texts:
5. P. T. Krein, “Elements of Power Electronics”, OUP

References

Electric Drives

PEM 202
Contact: 3L+1T
Credits: 04


Converter Control of DC Drives: Analysis of series and separately excited DC motor with single phase and three phase converters operating in different modes and configurations.

Chopper Control of DC Drives: Analysis of series and separately excited DC motors fed from different choppers for both time ratio control and current limit control, four quadrant control.

Design of DC Drives: Single quadrant variable speed chopper fed DC drives, Four quadrant variable speed chopper fed DC Drives, Single phase/ three phase converter, Dual converter fed DC Drive, current loop control, Armature current reversal, Field current control, Different controllers and firing circuits, simulation.

Inverter fed AC Drives: Analysis of different AC motor with single phase and three phase inverters Operations in different modes and configurations.

Cyclo-converter fed AC Drives: Analysis of different AC motor with single phase and three phase cycloconverters Operations in different modes and configurations.

AC Voltage controller fed AC Drives: Speed Control and braking. Analysis of different AC motor with single phase and three phase ac voltage controllers. Operations in different modes and configurations.


Text:
5. Bimal K Bose, “Modern Power Electronics and AC Drives” PHI

Reference:

Special Electrical machine

PEM 203
Contact: 3L+1T
Credits: 04

Stepper Motor: Introduction, Types, Hybrid stepper motor- construction, principle of operation, two phases energized at a time, conditions for operation, different configurations, VR Stepper motor- single stack and multi stack, Drive systems and circuit for open loop and Closed loop control of stepping motor. Dynamic characteristics. Single phase stepper Motor, Expression of voltage , current and torque for stepper motor and criteria for synchronization.

Switched Reluctance Motor: Constructional features, principle of operation, Design Aspects and profile of the SRM. Torque equation, Power converters and rotor sensing mechanism, expression of torque and torque-speed characteristics,

Permanent Magnet Materials: Permanent magnet materials, properties, minor hysteresis loop and recoil line, equivalent circuit, stator frames with permanent magnets,

Brushless DC Motor: Construction, operation, sensing and switching logic scheme, Drive and power circuit, Theoritical analysis and performance prediction, transient Analysis.

Linear Induction Motor: Construction and principle of operation of Linear Induction Motor, Approximate calculation of the force on rotor.

Text:
2. Reference:

Page 3 of 18
Generation of Nonconventional Energy

PEM 204(a)
Contact: 3L+1T
Credits: 04


POWER CONDITIONING CONVERTERS: DC Power conditioning converters – Maximum Power point tracking algorithms – AC power conditioners – Line commutated inverters – Synchronized operation with grid supply – Harmonic problem


INDUCTION GENERATOR: Self excited Induction Generator for isolated Power Generators – Theory of self excitation – Capacitance requirements – Power conditioning schemes – Controllable DC Power from SEIGs

OPTIMISATION TECHNIQUE: Wind / Solar PV integrated systems – selection of power conversion ratio – Optimization of system components – Storage

Text/References:

Advanced Mathematics -II

PEM 204(b)
Contact: 4L
Credits: 04

Advanced Matrix Theory: Computation of the greatest and the least eigen values of a matrix by power method, Modal matrix, Spectral matrix, Real Quadratic form.

Linear Programming: Graphical method, Simplex method, Charnes Big M Technique, Two phase Technique, Revised Simplex method.


Text/Reference:
Simmons DM : Nonlinear Programming for Operations Research, PHI
Bazara, Shetty and Sherali : Nonlinear Programming
S S Rao : Optimization Techniques, Wiley Eastern
Francis B Hildebrand : Methods of Applied Mathematics, 1992
Intelligent Control of Drives

**PEM 204(c)**
Contact: 4L
Credits: 04


**FUZZY LOGIC CONTROLLER:** Fuzzy to crisp conversion – Lambda cuts for fuzzy sets and relations – definition methods – structure of fuzzy logic controller – database – rule base – Inference engine

**APPLICATION AND DESIGN:** Applications of Neural network and Fuzzy system for single phase fully controlled converter, single phase ac voltage controller, DC Drive and AC Drive
Designing of controllers using Simulation Software Fuzzy Logic Toolbox – Modeling of DC Machines using Simulation Software and Simulink Toolbox

**Text Books:**

Non linear Phenomena in Switching Systems.

**PEM 205(a)**
Contact: 4L
Credits: 04

**Basics of Nonlinear Dynamics:** System, state and state space model, Vector field- Modeling of Linear, nonlinear and Linearized systems, Attractors , chaos, Poincare map, Dynamics of Discrete time system, Lyapunov Exponent, Bifurcations, Bifurcations of smooth map, Bifurcations in piece wise smooth maps, border crossing and border collision bifurcation

**Techniques for investigation of nonlinear Phenomena:** Techniques for experimental investigation, Techniques for numerical investigation, Computation of averages under chaos, Computations of spectral peaks, computation of the bifurcation and analyzing stability.

**Nonlinear Phenomena in DC-DC Converters:** Border collision in the Current Mode controlled Boost Converter, Bifurcation and chaos in the Voltage controlled Buck Converter with latch, Bifurcation and chaos in the Voltage controlled Buck Converter without latch, Bifurcation and chaos in Cuk Converter. Nonlinear phenomenon in the inverter under tolerance band control

**Nonlinear Phenomena in Drives:** Nonlinear Phenomenon in Current controlled and voltage controlled DC Drives, Nonlinear Phenomenon in PMSM Drives.

**Control of Chaos:** Hysteresis control, Sliding mode and switching surface control, OGY Method, Pyragas method, Time Delay control. Application of the techniques to the Power electronics circuit and drives.

Page 5 of 18
Reference:
1. S Banerjee, Dynamics for Engineers, John Wiley

Electrical Engineering Laboratory-III

PEM 291
Contact: 3P
Credits: 02
Hardware experiments / Software experiments / hardware simulation / software simulation on Electrical Engineering.

Electrical Engineering Laboratory-IV

PEMP 292
Contact: 4P
Credits: 02
Hardware experiments / Software experiments / hardware simulation / software simulation on Electrical Engineering.

Seminar-II

PEM 293
Contact: 3P
Credits: 02
Assigned Seminar on recent topics

Introduction to Management

MMAN 301
Contact: 4L
Credit: 4
To be prepared centrally

Power quality management

PEM 302(a)
Contact: 4L
Credits: 04

INTRODUCTION: Power Quality phenomena – Basic terminologies – various events in Power Quality – Causes for reduction in Power Quality — Power Quality Standards

VOLTAGE SAG: Causes of voltage sags – magnitude and duration of voltage sags – effect on adjustable AC Drives, DC drives, computers and consumer electronics – monitoring and mitigation of voltage sags.

INTERRUPTION: Origin of Long and Short interruptions – influence on various equipments – reliability of power supply – basic reliability evaluation techniques – monitoring and mitigation of interruptions


POWER QUALITY MEASUREMENTS: Interpretation and analysis of Power Quality Measurements, Active Filters as Power Quality Conditioners – Basic concept of Unified Power Quality Conditioners.
Text:


Reference:
4. Harmonic Distortion in the electric supply system”, – Technical Note No. 3 from Integral Energy Power Quality Centre, University of Wollongong, March 2000

High Voltage DC Transmission

PEM 302(b)
Credit: 4L
Credits: 04


CONVERTER: Pulse Number – Converter configuration – analysis of Graetz circuit – converter bridge characteristics – characteristics of 12 Pulse converter

HVDC CONTROLLERS: General principle of DC link control – converter control characteristics – system control hierarchy – firing angle control – current and extinction angle control – Dc link power control – high level controllers

FILTERS: Introduction to harmonics – generation of harmonics – design of AC filters – DC filters – carrier frequency and RI noise


Text/Reference:


PEM 391
Pre submission Defense of Dissertation (Project Work)
Credits: 04

PEM 392
Dissertation (Project Work) -Part-I
Credits: 10

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FOURTH SEMESTER:

PEM 491
Dissertation (Project Work) - completion
Credits: 14

PEM 492
Submission Defense of Dissertation (Project Work)
Credits: 8