M.Tech: Power Electronics and Drives

ELECTRICAL ENGINEERING DEPARTMENT
M.Tech. Programme

in

POWER ELECTRONICS AND DRIVE

SYLLABUS
FOR
CREDIT BASED CURRICULUM

DEPARTMENT OF ELECTRICAL ENGINEERING
MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY
JAIPUR-302017
Proposed Structure of New Scheme as per R & R Manual of PG Programmes in Power Electronics and Drive

M. Tech Programme Structure for Full Time

<table>
<thead>
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<th>Semester</th>
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## Programme Core

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## Professional Elective

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**Profession Elective (EPE-5 & EPE-6): To be offered by other department**

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DETAILED SYLLABUS

Programme Core

EET-606: POWER CONVERSION TECHNIQUES Credit: 3 (2 1 0)

Analysis of switched circuits- thyristor controlled half wave rectifier – R, L, RL, RC load circuits, classification and analysis of commutation

Single-Phase and Three-Phase AC to DC converters- half controlled configurations- operating domains of three phase full converters and semi-converters – Reactive power considerations.

Analysis and design of DC to DC converters- Control of DC-DC converters, Buck converters, Boost converters, Buck-Boost converters, Cuk converters

Single phase and Three phase inverters, Voltage source and Current source inverters, Voltage control and harmonic minimization in inverters.

AC to AC power conversion using voltage regulators, choppers and cyclo-converters, consideration of harmonics.

References:


EET-607: INDUSTRIAL CONTROL ELECTRONICS Credit: 3 (2 1 0)


Analog Controllers - Proportional controllers, Proportional – Integral controllers, PID controllers, derivative overrun, integral windup-cascaded control-Feedforward control-Digital control schemes- control algorithms-programmable logic controllers.

Signal conditioners-Instrumentation amplifiers – voltage to current, current to voltage, voltage to frequency, frequency to voltage converters; Isolation circuits – cabling; magnetic and electro static shielding and grounding.
Opto-Electronic devices and control, electronic circuits for photo-electric switches-output signals for photo-electric controls; Applications of opto-isolation, interrupter modules and photo sensors – Fibre optics – Bar code equipment, application of barcode in industry.


References:


EET-608: INTELLIGENT CONTROL TECHNIQUES Credit: 3 (2 1 0)

Introduction: Approaches to intelligent control; Architecture for intelligent control; Symbolic reasoning system; rule-based systems; AI approach; Knowledge representation; Expert systems.

Fuzzy Logic Control System: Motivation and basic definitions; Fuzzy arithmetic and Fuzzy relations; Fuzzy logic modeling and control; Fuzzy knowledge and rule bases; Fuzzy modeling and control schemes for nonlinear systems; Self-organizing fuzzy logic control; Fuzzy logic control for nonlinear time-delay system; Stabilization using fuzzy models; Fuzzy estimators; Adaptive fuzzy control.

ANN based Controllers and Estimators: Concept of Artificial Neural Networks and its basic mathematical model; McCulloch-Pitts neuron model; simple perceptron; Adaline and Madaline; Feed-forward Multilayer Perceptron; Learning and Training the neural network; Data Processing; Scaling; Fourier transformation; principal-component analysis and wavelet transformations; Hopfield network; Self-organizing network and Recurrent network; Neural Network based controllers and estimators.

Genetic Algorithm: Basic concept of Genetic algorithm and detail algorithmic steps; Adjustment of free parameters; Solution of typical control problems using genetic algorithm; Concept on some other search techniques like tabu search and ant-colony search techniques for solving optimization problems; Evolutionary Fuzzy logic controllers.

Case Studies: Identification and control of linear and nonlinear dynamic systems using Matlab-Neural Network toolbox; Stability analysis of Neural-Network interconnection systems; Implementation of fuzzy logic controller using Matlab fuzzy-logic toolbox; Stability analysis of fuzzy control systems.
References:

1. Padhy.N.P.; “Artificial Intelligence and Intelligent System”; Oxford UniversityPress.
2. KOSKO;B. "Neural Networks and Fuzzy Systems”; Prentice-Hall of India Pvt. Ltd.
4. KLIR G.J. & FOLGER T.A. "Fuzzy sets; uncertainty and Information"; Prentice-Hall of India Pvt. Ltd.

EET-609: SWITCHED MODE POWER CONVERSION  Credit: 3 (2 1 0)


Basic concepts of Switched Mode power converters, DC-DC converters Characteristics, constituent elements, operating principles.

Steady state analysis, stress and sizing of elements, control methods, duty ratio, current programmed, frequency programmed and sliding mode control, Dynamic analysis and frequency domain models.

Classification of resonant converters, Basic resonant circuit concepts, Load resonant converters, Resonant switch converters, Zero voltage switching.

Design of feedback compensators, unity power factor rectifiers, resistor emulation principle and applications to rectifiers.

References:


EET-622: ELECTRIC DRIVES AND THEIR CONTROL  Credit: 3 (2 1 0)


Dynamics of Electric Drives: Parts of electric drives electric motors, power modulators, sources, control unit, and mechanical system. Fundamental torque equations. Multi-quadrant operation.

Equivalent values of drive parameters-loads with rotational motion and translational motion,
components of load torque, nature and classification of load torques. Dynamic conditions of a drive system. Energy loss in transient operations, load equalization.
DC Motor Drives: Starting, Braking, and speed control Transient Analysis of separately excited motor with armature and field control, energy losses during transient operation. Phase controlled converter DC drives, dual-converter control of DC drive, power factor, supply harmonics and ripple in motor current. Chopper control DC drives. Source Current harmonics.
3-Phase Induction Motor Drives: Starting, Breaking and Transient Analysis. Calculation of energy losses. Speed Control, Staler Voltage control. Variable Frequency control from voltage and current sources, Slip power recovery-Static Scherbius and Cramer Drives.
Synchronous Motor Drives: Starting, Pull in and Braking of Synchronous motor. Speed control-variable frequency control, Cycloconverter control.
Brushless DC Motor, Linear Induction Motor, Stepper Motor and Switched Reluctance Motor Drives: Important Features and applications.

EEP602: POWER ELECTRONICS & DRIVES LAB                                      Credit: 3 (2 1 0)

Experiments and computer simulations on:
Single phase, three phase Semi converters and Full converters,
DC-DC Choppers using SCRs and Self communicating Devices.
Single phase and three phase inverters using IGBTs,
AC-AC voltage regulators.
DC and AC drives

Professional Elective
EET-610: EHV AC TRANSMISSION SYSTEM  
Credit: 3 (2 1 0)

Bulk power transmission over long distance, need for EHV transmission problems of EHV transmission, Power Handling capacity and surge impedance loading. Current carrying capacity of conductor. Choice of economic voltage, standard transmission voltages.

Bundled Conductors: Properties of bundled conductors, geometric mean radius of bundle, inductance and capacitance, Voltage gradients of conductors, maximum surface voltage gradients of bundled conductors, maximum surface electric fields for bundled and single conductor lines. Electrostatic fields of EHV lines. Effect of E.S. field on Humans, Animals and Plants.


EET-615: FLEXIBLE AC TRANSMISSION SYSTEM  
Credit: 3 (2 1 0)


EET-616: INTEGRATED ENERGY SYSTEMS  
Credit: 3 (2 1 0)


EET-618: MODERN CONTROL THEORY  
Credit: 3 (2 1 0)


Microprocessor Based Control Systems: Digital Quantization, Positional Control System, Temperature Control System, Stepper Motor Drive circuits and Control of a Manipulator Arm.

Optimization: Time Optimal System (without proof of control law), Calculation of Switching Trajectories for second order systems. Optimal Control System based on Quadratic performance Indices (proof through Liapunov's function), Basic concepts of Model Reference Control System and Adaptive System.

Pontryagin's maximum principle, constrained and unconstrained input, Dynamic Programming-optimality principle, Discrete and Continuous Dynamic Programming.

**EET-620: ADVANCED THEORY AND ANALYSIS OF AC MACHINES** **Credit: 3 (2 1 0)**


**EET-621: EXCITATION OF SYNCHRONOUS MACHINES AND THEIR CONTROL** **Credit: 3 (2 1 0)**


D.C. Excitation Systems: configuration of DC excitation system with main and pilot exciters. Amplidyne and magnetic amplifier. Automatic voltage regulator with magnetic amplifier and Amplidyne. Limitation and problems of DC excitation systems. Improvement in DC excitation system.


AC Separately Excitation Systems. (Alternator- Rectifier Excitation System): Scheme of alternator-rectifier excitation system with (i) diode rectifier and (ii) thyristor rectifier.
Comparison and Application of these schemes. Harmful effects of static excitation systems or system machine components, means of prevention.


Introduction to Superconducting Exciter.


**EET-625: HVDC TRANSMISSION**  
*Credit: 3 (2 1 0)*

Rectification: The 3-phase Bridge rectifier or Graetz circuit, Inversion, Kinds of D.C links, Paralleled and Series connection of thyristors, Power flow in HVDC transmission system.

Converter Station: Major components of a converter station-converter unit, filters, reactive power source. Ground return and ground electrode.

Basic principles of DC link control: Converter control characteristics, firing angle control and extinction angle control. Parallel operation of D.C. link with A.C. transmission line.

Introduction to Multiterminal HVDC Systems and HVDC Circuit Breakers, Comparison between AC and DC transmissions, break even distance for overhead transmission lines and underground cables. Application of HVDC transmission.

Text books

**EET-626: DIGITAL CONTROLLER APPLICATION IN POWER CONVERTERS**  
*Credit: 3 (2 1 0)*

Pin Multiplexing (MUX) and General Purpose I/O Overview, Multiplexing and General Purpose I/O Control Registers .Introduction to Interrupts, Interrupt Hierarchy, Interrupt Control Registers, Initializing and Servicing Interrupts in Software.

ADC Overview , Operation of the ADC in the DSP , Overview of the Event manager (EV) , Event Manager Interrupts , General Purpose (GP) Timers , Compare Units, Capture Units And Quadrature Enclosed Pulse (QEP) Circuitry , General Event Manager Information

Introduction to Field Programmable Gate Arrays – CPLD Vs FPGA – Types of FPGA, Xilinx XC3000 series , Configurable logic Blocks (CLB), Input/Output Block (IOB) – Programmable Interconnect Point (PIP) – Xilinx 4000 series – HDL programming –overview of Spartan 3E and Virtex II pro FPGA boards- case study.

Controlled Rectifier, Switched Mode Power Converters, PWM Inverters, DC motor control, Induction Motor Control

References
2. XC 3000 series datasheets ( version 3.1). Xilinx,Inc.,USA, 1998
3. XC 4000 series datasheets ( version 1.6). Xilinx,Inc.,USA, 1999
4. Wayne Wolf,” FPGA based system design “, Prentice hall, 2004

EET-627: ADVANCED ELECTRICAL DRIVES  Credit: 3 (2 1 0)

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

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

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

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

**EET-628: PWM CONVERTERS AND APPLICATIONS**

Credit: 3 (2 1 0)

AC/DC and DC/AC power conversion, overview of applications of voltage source converters, pulse modulation techniques for bridge converters. Bus clamping PWM, space vector based PWM, advanced PWM techniques, practical devices in converter; calculation of switching and conduction losses. Compensation for dead time and DC voltage regulation; dynamic model of a PWM converter, multilevel converters; constant V/F induction motor drives. Estimation of current ripple and torque ripple in inverter fed drives; line – side converters with power factor compensation. Active power filtering, reactive power compensation; harmonic current compensation.

**References**

**EET-629: EMBEDDED SYSTEM DESIGN**

Credit: 3 (2 1 0)


Processor & Memory Organization: Structural units in processor - Processor selection - Memory devices - Memory selection - Memory Allocation & Map – Interfacing


Hardware and Software Co-Design: Embedded system design and co- design issues in software development - Design cycle in development phase for Embedded System - Use of ICE & Software tools for development of ES - Issues in embedded system design.
EET-630: OPTIMIZATION ALGORITHMS  

Credit: 3 (2 1 0)

Optimization Fundamentals – Definition, Classification of problems, Unconstrained and constrained optimization, Optimality conditions.

Linear Programming – Simplex Method, Duality, Sensitivity methods.


Dynamic Programming and Integer Programming – Interior point methods, Karmakar’s algorithm, Dual affine, Primal Affine, Barrie algorithm


References:


EET631: DIGITAL SIGNAL PROCESSING & APPLICATIONS  

Credit: 3 (2 1 0)


Introduction to Multirate Signal Processing - Decimation - Interpolation - Case Studies on Speech Coding, Transform Coding – DSP based measurement system.


EET-632: COMPUTER NETWORKS Credit: 3 (2 1 0)


Data link layer - design issues, Data link protocols. Medium access sub layer - channel allocations, Multiple Access protocols, IEEE protocols.

Network layer - Design issues, routing algorithms, congestion control algorithms, QoS , Transport layer- Design issues, Connection management .

Application layer – DNs, Electronic mail, World Wide Web, multimedia, Cryptography, Internet transport protocols - TCP and UDP

References


EET-633: RENEWABLE POWER GENERATION AND CONTROL Credit: 3 (2 1 0)


Introduction to PV-Cells, Array, Solar power extraction using PV-Cells, I-V Characteristics, PV-Inverters without D.C. to D.C. converters, Grid interfacing-with isolation, without isolation, Maximum power point tracking-Methods, PV-Inverters with D.C. to D.C. converters-on low frequency side and high frequency side with isolation, without isolation.


EET-634: ADVANCES IN POWER TRANSMISSION & DISTRIBUTION Credit: 3(2 1 0)

Text / References
5. Flexible Ac Transmission Systems, Yong-Hua Song, Allan T. Johns, IEE publication

EET-635: APPLICATIONS OF POWER ELECTRONICS IN POWER SYSTEMS
Credit: 3(2 1 0)
Steady state and dynamic problems in AC systems: Flexible AC transmission systems (FACTS), Principles of series and shunt compensation, Description of static var compensators (SVC), Thyristor Controlled series compensators (TCSC), Static phase shifters (SPS), Static
condenser (STATCON), Static synchronous series compensator (SSSC) and Unified power flow controller (UPFC),

**Modelling and Analysis of FACTS controllers**: Control strategies to improve system stability, Power Quality problems in distribution systems

**Harmonics**: Harmonics creating loads, modelling, harmonic propagation, Series and parallel resonances, harmonic power flow, Mitigation of harmonics, filters, passive filters, Active filters, shunt, series hybrid filters, voltage sags & swells, voltage flicker, Mitigation of power quality problems using power electronic conditioners, IEEE standards, HVDC Converters and their characteristics, Control of the converters (CC and CEA), Parallel and series operation of converters.

**Text / References**


**EET-636: MODELLING & SIMULATION OF POWER ELECTRONIC SYSTEMS**
Credit: 3(2 I 0)

**Modelling of Power Electronic Converters**: Modelling of semiconductor devices, Switch realization– single quadrant and two quadrant switches, switching losses

**Review of DC-DC converters**: Steady-state analysis of converter in continuous and discontinuous modes (CCM & DCM), and estimation of converter efficiency, Development of circuit model for simulating dynamic operating conditions in CCM & DCM, Feedback control for converters

**Controller design Dynamic Modelling of Electrical Machines**: Modelling of DC machines, Modelling of three phase Induction machine, Reference frame theory – ARF, RRF, SYRF, SRF, equations of transformation, voltage equations, torque equations, analysis of steady-state operation, acceleration characteristics, effect of loading and operation with non-sinusoidal voltages
**Choice of simulators:** Power Electronic Circuit simulation using PSPICE, Analysis of Dynamic behaviour of Electrical Machines using MATLAB/SIMULINK.

**Reference:**


**EET-637: APPLICATION OF POWER ELECTRONICS IN SMART GRID**

*Credit: 3 (2 1 0)*

**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 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, ECM cases in distributed power system.

**High Frequency AC Power Distribution Platform:** Introduction, high frequency in space applications, telecommunications, computer and commercial electronics system, 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**

EET-638: POWER SYSTEM QUALITY  

Power quality: concepts and definition, Power quality and voltage quality, Power quality standards, General classes of power quality problems, CBEMA and ITI Curves, Power quality terms, Power frequency variations
Long-duration voltage variations, Short-duration voltage variations, Voltage imbalance, Waveform distortion, Voltage sags and interruptions, sources of sags and interruptions
Estimating voltage sag performance, Sensitivity of Equipment to voltage sag.
Transients: origin and classifications, capacitor switching transient, lightning-load switching, impact on users, protection, mitigation.
Power system harmonics: harmonics, inter-harmonics, sub-harmonics, Difference between harmonics and transients, voltage and current distortion, harmonic indexes, sources of harmonic distortion, effects of harmonic distortion, mitigation and control techniques, harmonic filters.
Power quality conditioners: shunt and series compensators, DSTATCOM-Dynamic voltage restorer, unified power quality conditioners-case studies

Text/Reference
3. C.Sankaran, “Power Quality” CRC Press