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

Semester	Course Code Credits (L T P)						Semester Credits
I	EET-606 3(2 1 0)	EET-607 3(2 1 0)	EET-608 3(2 1 0)	EET-609 3(2 1 0)	EET-622 3(2 1 0)	EEP-602 2(0 0 3)	17
II	PE-1 3(2 1 0)	PE-2 3(2 1 0)	PE-3 3(2 1 0)	PE-4 3(2 1 0)	PE-5 3(2 1 0)	PE-6 3(2 1 0)	18
III	EES-702 Seminar 4		EED-704 Dissertation 16				20
IV	EED-706 Dissertation 18						18
Total							73

M.Tech. Programme Structure for Part Time

Semester	Courses					Credits
I	EET-606 3(2 1 0)	EET-607 3(2 1 0)	EET-608 3(2 1 0)			09
II	PE-1 3(2 1 0)	PE-2 3(2 1 0)	PE-3 3(2 1 0)			09
III	EET-609 3(2 1 0)	EET-622 3(2 1 0)	EEP-602 2(0 0 3)	EES-702 Seminar 4		12
IV	PE-4 3(2 1 0)	PE-5 3(2 1 0)	PE-6 3(2 1 0)			09
V	EED-704 Dissertation 16					16
VI	EED-706 Dissertation 18					18
					Total	73

Programme Core

Course Code	Title of the Subject	PRS	PRE	CWS	MTE	ETE
EET-606	Power Conversion Techniques	-	-	20	30	50
EET-607	Industrial Control Electronics	-	-	20	30	50
EET-608	Intelligent Control Techniques	-	-	20	30	50
EET-609	Switched Mode Power Conversion	-	-	20	30	50
EET-622	Electric Drives and their Control	-	-	20	30	50
EEP-602	Power Electronics & Drives Lab	60	40	-	-	-
EES-702	Seminar	-	-	-	-	-
EED-704	Dissertation	-	-	-	-	-
EET-706	Dissertation	-	-	-	-	-

Professional Elective

Course Code	Title of the Subject	PRS	PRE	CWS	MTE	ETE
EET-610	EHV AC Transmission System	-	-	20	30	50
EET-615	Flexible AC Transmission Systems	-	-	20	30	50
EET-616	Integrated Energy Systems	-	-	20	30	50
EET-618	Modern Control Theory	-	-	20	30	50
EET-620	Advanced Theory and Analysis of AC Machines	-	-	20	30	50
EET-621	Excitation of synchronous Machines and their Control	-	-	20	30	50
EET-625	HVDC Transmission	-	-	20	30	50
EET-626	Digital Controller Application in Power Converters	-	-	20	30	50
EET-627	Advanced Electrical Drives	-	-	20	30	50
EET628	PWM Converters and Applications	-	-	20	30	50
EET-629	Embedded System Design	-	-	20	30	50
EET-630	Optimization Algorithms	-	-	20	30	50
EET-631	Digital signal processing & applications			20	30	50
EET-632	Computer Networks	-	-	20	30	50
EET-633	Renewable Power Generation and Control	-	-	20	30	50
EET-634	Advances in Power Transmission & Distribution	-	-	20	30	50
EET-635	Applications of Power Electronics in Power Systems	-	-	20	30	50
EET-636	Modeling & Simulation of Power Electronic Systems	-	-	20	30	50
EET-637	Application of Power Electronics in Smart Grid	-	-	20	30	50
EET638	Power System Quality	-	-	20	30	50

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

Code	Courses from Professional Electives	PRS	PRE	CWS	MTE	ETE
		-	-	20	30	50

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:

1. Ned Mohan, Undeland and Robbin, "Power Electronics: converters, Application and design", John Wiley and sons.Inc, Newyork, 1995.

2. Rashid M.H., "Power Electronics Circuits, Devices and Applications", Prentice Hall India, New Delhi, 1995.

3. P.C Sen., "Modern Power Electronics", Wheeler publishing Co, First Edition, New Delhi, 1998.

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

Review of switching regulators and switch mode power supplies-Uninterrupted power supplies-OFF-LINE AND ON-LINETOPOLOGIES-Analysis of UPS topologies-solid state circuit breakers-solid-state tap-changing of transformer.

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.

Stepper motors – types, operation, control and applications; servo motors- types, operation, control and applications – servo motor controllers – servo amplifiers – linear motor applications-selection of servo motor.

References:

1. Michael Jacob, "Industrial Control Electronics – Applications and Design", Prentice Hall, 1988.

2. Thomas, E. Kissel, "Industrial Electronics" PHI, 2003.

3. James Maas, "Industrial Electronics", Prentice Hall, 1995.

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.
3. Jacek.M.Zurada; "Introduction to Artificial Neural Systems";Jaico PublishingHouse.
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)

Reactive Elements in Power Electronic Systems, Design of inductor, Design of transformer, Capacitors for power electronic applications.

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.

Text book:

1. Issa Batarseh, "Power Electronic Circuits", John Wiley, 2004.

References:

1. Switched Mode Power Conversion, Course Notes, CCE, IISc, 2004.

2. Philip T Krein, "Elements of Power Electronics”, Oxford Press.

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

Characteristics of Electric Motors: Characteristics of DC motors, 3-phase Induction motors and Synchronous motors. Starting and Breaking of Electric motors. Status of DC and AC Drives.

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.

Motor Power Rating: Power losses of motors, heating and cooling of electric motors. Thermal model of motor for heating and cooling, classes of motor duty, Determination of motor rating, continuous duty, short time duty and intermittent periodic duty. Equivalent current, torque and power for fluctuating and intermittent loads.

Control of electric Drives: Modes of operation. Closed-loop control of drives. Current-limit control. Closed-loop torque, and speed control. Closed-loop control of multi motor drives. Speed and current sensing. Phase-locked-loop control.

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.

Energy Conservation in Electrical Drives: Losses in electrical drive system. Measures for energy conservation in electric drives, Use of efficient motor, Energy efficient operation of drives, Improvement of power factor and quality of supply.

Text book:

1. G.K. Dubey, “Fundamentals of electrical drives”, Narosa,2010

References:

1. Vedam Subrahmanyam, “Electric Drives. Concepts and Applications”, McGraw Hill ,2011.

2. Leonhard, Werner, “Control of Electrical Drives”, Springer,2001

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

Text book:

1. M B Patil, V Ramnarayan and V T Ranganathan, "Simulation of Power Electronic Circuits", Narosa, 2009
2. M H Rashid, "Power Electronics: Devices, Circuits and Applications", Pearson, 2017

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.

Series and Shunt compensation: Effect of series capacitors, location of series capacitors. Sub-synchronous resonance in series-capacitor compensated lines and counter measures. Shunt compensation - Variation of no-load receiving end voltage, Static VAR Systems: TCR-FC, TCR, TSC-TCR and MSC-TCR Schemes.

Text book:

1. N.G. Hingorani& Laszlo Gyugyi , Understanding FACTS , IEEE Press, 2000.

References:

1.E.W. Kimbark. EHV-AC and HVDC Transmission Engineering & Practice, Khanna Publishers.

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

[i] Facts Concept and General System Considerations: Conventional reactive power compensation, Theory of Power Transmission Control, Basic Types of Facts Controllers, Brief description and Definitions of FACTS Controllers, shunt ,series and combined shunt and series Connected Controllers.

[ii] Static Series Compensators: GCSC,TSSC,TCSC, and SSSC: Objective of Series Compensation,

Concept of Series Capacitive Compensation, Voltage Stability, Improvement of transient stability, Variable Impedance Type Series Compensators, GTO thyristor-Controlled Series Capacitor(GCSC),Thyristor-Switched Series Capacitor (TSSC),Thyristor-Controlled Series Capacitor (TCSC),Switching Converter Type Series Compensators: Static Synchronous Series Compensator (SSSC).

[iii] Static Shunt Compensators: SVC and STATCOM: Objective of Shunt Compensation, Methods of Controllable Var Generation, Variable Impedance Type Static Var Generators, Switching Converter with TSC and TCR, Static Var Compensators: SVC and STATCOM, Comparison Between STATCOM and SVC, V-I and V-Q Characteristics, Transient Stability, Response Time, Capability to Exchange Real Power.

[iv] Static Voltage and Phase angle Regulators: TCVR and TCPAR: Objective of Voltage and Phase Angle Regulators, Power Flow Controlled by Phase Angle Regulator, Approaches to Thyristor-Controlled Voltage and Phase Angle Regulators (TCVRs and TCPARs): Continuously Controllable Thyristor Tap Changers, Thyristor Tap Changer with Discrete Level Control, Thyristor Tap Changer Valve Rating Considerations.

[v] Combined Compensators: Unified Power Flow Controller (UPFC) and Interline Power Flow Controller (IPFC): The Unified Power Flow Controller, Basic Operating Principles, Impedance Real and Reactive Power Flow Control, Comparison of UPFC to Series Compensators and Phase Angle Regulators, Basic Control System for P and Q Control, The Interline Power Flow Controller (IPFC), Basic operation principle and Characteristics.

Text Books:

1. . Flexible AC Transmission Systems: Modelling and Control, Springer,2012

Reference Books:

1. N.G. Hingorani & Laszlo Gyugyi, Understanding FACTS, IEEE Press, 2000.

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

Pattern of fuel consumption: Agricultural, domestic, industrial and community needs. Projection of Energy Demands, substitution of conventional sources by alternative sources and more efficient modern technologies. Potential of Solar, Wind, Biogas, Natural Gas, Forest produce, Tidal, Geothermal, Minihydro and other modern applications. Hybrid and Integrated Energy Systems. Total Energy concept and Waste heat utilization.

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

[**i**] **Discrete Time Systems**: Z-Transform Method, Sampled Data Control Systems, Digital Controller, Sample and Hold Operation, Frequency consideration in Sampling and Reconstruction, Z-transformation, Solution of Differential & State Equations by 'Z' Transform Method, The Inverse Z-Transform, Pulse Transfer Function and Stability in Z-plane.

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[ii] State-space model specifications: Transform Design of Digital Controls & State Space Concepts: Design Specifications, Design on the 'W'-plane, 'W plane & 'Z' plane. The Cayley Hamilton Theorem, Concepts of Controllability and Observability**.**

[iii] Stability: Generalized Stability Criterion (d-partition technique), Pole Assignment method, Lyapunov's method, Lure's transformation, Popov's criterion, introduction to stochastic process

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

[v] 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 Lyapunov'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.

Text book:

1. Thomas Kailath, Linear Systems, the University of Michigan, Prentice-Hall.
2. M. Gopal, Digital control and state variable methods: conventional and intelligent control systems, Tata McGraw hill education private limited, New Delhi.
3. K. Ogata, Modern Control Engineering, Automatic control, Prentice Hall.
4. R. C.Dorf, R.H. Bishop, Modern control systems, Pearson Education, Pearson prentice hall.
5. D. Subbaram Naidu, Optimal control systems, CRC press.

Reference Books:

1. Linear Algebra and Its Applications. Gilbert Strang,
2. P. N. Paraskevopoulos, Modern Control Engineering, Marcel Dekker, New York, USA.
3. R. L. Williams II, D. A. Lawrence, Linear state-space control systems, John Willey & Sons, INC, Canada.
4. F. Lin, Robust Control Design: An Optimal Control Approach, John Willey & Sons ltd, USA.

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

Physical model, Different reference frame, Transformations, Primitive Machine, Dynamic variable, Formulation of dynamic equations of a generalized machine, Maxwell equations; Electric field of Transformers, Shaft voltages and fluxes, bearing currents, induction motor modelling, oscillations In Induction machines, Asymmetries in stator and rotor windings, Asynchronous-synchronous Operation of synchronous machine; Modelling, Operational Impedances, Time constants, Stability, Power angle characteristics, Symmetrical and Asymmetrical short circuit analysis, Measurement of Reactance, Power Systems.

Text Books:

1 P.S. Bimbhra, "Generalized Theory Of Electrical Machine"Khanna,1981.

Reference Books:

1. P.C. Krause "Analysis of Electric Machinery and Drive Systems", Wiley,2010

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

1. **Excitation Systems:** Principal Controls of a generating unit. Arrangement of excitation components, voltage response-ratio. Excitation specifications. Ceiling voltage, time constant and response of excitation systems. Requirements of excitation systems: Classification of excitation systems.

2. **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.
3. **AC Shunt Excitation Systems (Static Rectifier Excitation Systems):** Static thyristor rectifier schemes. Transient Response during fault condition. Use of booster transformer. Application for shunt excitation systems.
4. **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 on system machine components, means of prevention, shaft and bearing currents.
5. **Brushless Excitation Systems:** Brush-slip ring problem. Scheme of Brushless excitation system with rotating diode. Control, protection and monitoring of Brushless excitation system .Introduction to brushless excitation system with rotating thyristors. Introduction to Superconducting Exciter.
6. **Automatic Voltage Regulator (AVR):** Solid state automatic voltage regulator scheme. Auto and manual follow-up. Thyristor converter and AVR protection. Introduction to Digital AVR.
7. **Excitation Control:** Introduction to power stabilizing signal-speed, frequency and power signals. Rotor current limiter, MVAR limiter. Effect of excitation on generator power limits, Dynamic and Transient stabilities.

Text Books:

1. Steam Turbine Generator Excitation System and Application by Li Ji Cheng.
2. Steam Turbine Generator Excitation System Modernization by Schaefer R C, Basler Electric Co; Highland, IL, USA.

Reference Books:

1. Published literature on all types of excitation systems for Synchronous Generators in AIEE and IEEE, USA.

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

1. K.R. Padiyar, HVDC Power Transmission System, Wiley Estern Limited.
2. E.W. Kimbark. EHV-AC and HVDC Transmission Engineering & Practice, Khanna Publishers.

EET-626: DIGITAL CONTROLLER APPLICATION IN POWER CONVERTERS

Credit: 3 (2 1 0)

Introduction to the C2xx DSP core and code generation, The components of the C2xx DSP core, Mapping external devices to the C2xx core, peripherals and Peripheral Interface, System configuration registers, Memory, Types of Physical Memory , memory Addressing Modes , Assembly Programming using C2xx DSP, Instruction Set, Software Tools.

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

1. Hamid.A.Toliyat and Steven G.Campbell " DSP Based Electro Mechanical Motion Control " CRC Press New York , 2004
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-convertor 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.

Text Books:

1. R. Krishnan, "Electric Motor Drives: Modeling, Analysis, and Control" Prentice Hall, 2001
2. B. K. Bose – Modern Power Electronics and AC Drives, Prentice Hall publication, 1st edition, 2001.

Reference Books:

3. G.K, Dubey, "Power semiconductor-controlled Drives", Prentice Hall international, New Jersey, 1989.

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

1. Mohan, Undeland and Robbins,' Power Electronics; Converters, Applications and Design', John Wiley and Sons, 1989.
2. Erickson R W,' Fundamentals of Power Electronics', Chapman and Hall, 1997.
3. Vithyathil J,'Power Electronics: Principles and Applications ', McGraw Hill, 1995

EET-629: EMBEDDED SYSTEM DESIGN Credit: 3 (2 1 0)

Embedded System -Types of Embedded System - Requirements of Embedded System - Issues in Embedded software development - Applications.

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

Devices - Device Drives & Buses For Device Networks: I/O devices - Timers & Counter devices - Serial Communication - Communication between devices using different buses. Device drives - Parallel and serial port device drives in a system - Interrupt servicing mechanism - context and periods for context switching - Deadline and Interrupt Latency.

Programming & Program Modeling Concepts : Program elements - Modeling Processes for Software Analysis - Programming Models - Modeling of Multiprocessor Systems - Software algorithm Concepts -Design -Implementation -Testing -Validating -Debugging - Management and maintenance - Necessity of RTOS.

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.

References

1. C. H. Roth, Digital System Design, PWS, 1998.
2. J. F. Wakerly, Digital Design, PHI, 3rd Edition., 2001
3. W. Fletcher, An Engineering Approach to Digital Design, PHI.
4. M. J. Sebastian Smith, Application Specific Integrated Circuits, Addison-Wesley, 1999.

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.

Nonlinear Programming – Powel's method, Steepest descent method, conjugate gradient method, Newton's method, GRG method, Sequential quadratic programming, Penalty function method, Augmented Lagrange multiplier method.

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

Meta- Heuristic Optimization – Simulated annealing, Evolutionary Programming, Genetic Algorithm, Swarm optimization and other nature inspired algorithms.

References:

1. Rao S. S., "Engineering Optimization", New Age International Pvt Ltd.

2. Gill Murray and Wright, "Practical Optimization", Academic Press.

3. Laurence A. Wolsey, "Integer Programming", John wiley and Sons.

4. Fred Glover, G. A. Kochenberger, "Handbook of Metaheuristics", Kluwer Academic Publishers.

EET631: DIGITAL SIGNAL PROCESSING & APPLICATIONS Credit: 3 (2 1 0)

Review of Discrete – Time Signal & System representation in Z – Transform domain – Inverse Z – Transform – Properties – System characterization in Z – domain -- Equivalence between Fourier Transform and the Z-Transform of a Discrete signal.

Sampling in Fourier domain - Discrete Fourier Transform and its properties – Linear filtering using DFT – Resolution of DFT - FFT Algorithm – Radix-2 FFT Algorithm - DIT & DIF Structures - Higher Radix schemes.

Classification of filter design - Design of IIR filters – Bilinear transformation technique – Impulse invariance method – Step invariance method. FIR filter design – Fourier series method - Window function technique - Finite Word Length Effects.

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

References:

1. Ludemann L. C., "Fundamentals of Digital Signal Processing", Harper and Row

publications, 1986.

2. Antoniou A., "Digital Filters – Analysis and Design", Tata Mc-Graw Hill, 1980.

3. Oppenheim and Schaffer, 'Discrete time Signal processing', PHI, 1989.

4. P.P. Vaidhyanathan, " Multirate systems and filter banks", PHI, 1993.

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

Computer Network – Hardware and Software, OSI and TCP reference Model, Transmission media, Wireless transmission, public switched telephone network - Structure, multiplexing and switching.

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

1. James F. Kurose and Keith W. Ross, 'Computer Networking', 2nd Edition, Pearson

Education, 2003.
2. Tanenbaum, A.S., 'Computer Networks', 4th Edition, Prentice Hall of India, 2003.
3. Stallings, W., 'Data and Computer Communication',PHI,5th edition, 2000.

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

Introduction to Renewable Energy Systems: Wind power, Hydropower, Solar energy-Biomass, Bio-fuel, Geothermal Heat energy, Solar-thermal plants, Applications.

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.

Wind Energy Sources and potentials, Evaluation of Wind Intensity, Topography, General Classification of Wind Turbines-Rotor Turbines, Multiple-Blade Turbines, Drag Turbines, Lifting Turbines, System TARP–WARP, Generators and speed control used in wind power energy, Wind Power Control: Fixed speed with capacitor bank, Rotor resistance control, DFIG, Synchronous Generator-external magnetized, Synchronous Generator-permanent magnets.

Fuel Cells: Fuel cells, Commercial Technologies for Generation of Electricity, Constructional Features of Solid Oxide Fuel Cells, Constructional Features of Proton Exchange Membrane Fuel Cells, Load Curve Peak Sharing with Fuel Cells, Advantages and Disadvantages of Fuel Cells, voltage step-up using D.C.-D.C. converter- with and without battery storage, Voltage controller for Fuel cell using D.C. – D.C. converter, Inverter interaction with fuel cell for A.C. loads, A.C. Voltage build-up and controller for fuel cells- using power converters and transformers (isolation).

References

1. G. D. Rai , “Non-conventional Energy Sources”, Khanna Publishers, 2001.

2. P. S. Sukhatme , “Solar Energy”, MC Grawhill, 2017.

3. Remus Teodorescu, Marco Liserre, Pedro Rodríguez, “Grid Converters for Photovoltaic and Wind Power Systems”, Wiley, 2011.

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

Basic theory of line compensation. FACTS devices, The FACTS optimisation problem. Transient and dynamic stability enhancement using FACTS components. Concepts of modern grid.

Introduction to distribution automation, Layout of substations and feeders, Optimum siting and sizing of substations Distribution system load flow, configuration of distribution system, optimum capacitor placement. Optimum feeder switching for loss minimization and load control. Distribution system restoration. Distribution system monitoring and control: SCADA, Concept of modern distribution systems.

Text / References

1. Rakesh Das Begmudre, Extra High Voltage AC Transmission Engineering, Wiley Estern Limited.
2. K.R. Padiyar, HVDC Power Transmission System, Wiley Estern Limited.
3. E.W. Kimbark. EHV-AC and HVDC Transmission Engineering & Practice, Khanna Publishers.
4. Math H. J. Bollen, Understanding Power Quality Problems: Voltage Sags and Interruptions, Wiley-IEEE Press.
5. Flexible Ac Transmission Systems, Yong-Hua Song, Allan T. Johns, IEE publication
6. Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems, Narain G. Hingorani, Laszlo Gyugyi

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

1. N.G. Hingorani & Laszlo Gyugyi ,Understanding FACTS , IEEE Press, 2000.

2. E. F. Fuchs & Mohammad A.S. Masoum, Power Quality in Power Systems and Electrical Machines, Elsevier Academic Press 2008.
3. K.R. Padiyar, FACTS controllers in power transmission and distribution, New Age International publishers, New Delhi, 2007.
4. K.R. Padiyar, HVDC Power Transmission Systems, New Age International publishers, New Delhi, 1999.

EET-636: MODELLING & SIMULATION OF POWER ELECTRONIC SYSTEMS

Credit: 3(2 1 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:

1. R.W. Erickson, DraganMaksimovic, “Fundamentals of Power Electronics”, Springer, 2005.
2. P.C. Krause, O. Wasynczuk, S.D. Sudhoff, “Analysis of Electrical Machinery & Derive Systems” , Wiley Student Edition, 2002.

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

Strzelecki Benysek, "Power Electronics in Smart Electrical Energy Networks", Springer, 2008.

Clark W Gellings, "The Smart Grid: Enabling Energy Efficient and Demand Side Response", CRC Press, 2009.

EET-638: POWER SYSTEM QUALITY **Credit: 3 (2 1 0)**

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

1. Surya Santoso, H. Wayne Beaty, Roger C. Dugan, Mark F. McGranaghan, “Electrical Power Systems Quality”, McGraw-Hill, 2002.
2. Bollen, M.H.J, “Understanding Power Quality Problems: Voltage sags and interruptions”, IEEE Press, New York, 2000.
3. C.Sankaran, “Power Quality” CRC Press
4. ArindamGhosh, Gerard Ledwich, “Power quality enhancement using custom power devices”, Springer, 2002.
5. Angelo B. Baggini, “Handbook of power quality” , Wiley, 2008
6. Arrillaga, J, Watson, N.R., Chen, S.,“Power System Quality Assessment”, Wiley, NewYork, 2000