

M.TECH - POWER ELECTRONICS

Department of Electrical and Electronics Engineering

Power Electronics plays an important role in processing and controlling the flow of electric energy by supplying voltages and currents in forms that are optimally suited for the user loads from a few watts to several mega watts. The application areas include wide spectrum such as Heating and Lighting Control, AC and DC Power Supplies, Electric Motor Control, Energy Conservation, Process Control and Factory Automation, Transportation, HVDC, FACTS Devices, Power Quality Improvement etc.

Power Electronics encompasses many fields within Electrical engineering.

The PG program includes courses in Mathematics, Cultural Education and the core subject areas. In core subject areas, emphasis is given on power processors with recent and emerging power switching devices, electrical machines and their control, measurement and processing of signals, signal processors, control systems and digital system design required to build any power electronic equipment with necessary controllers. The program offers electives for the students to enhance the knowledge of emerging machines, areas of power electronics applications and techniques to optimize the designs.

The Program culminates with a project work in which the students are encouraged to work on specific areas involving design, simulation, fabrication and testing of any power electronics system having research/industrial application values.

CURRICULUM

First Semester

Course Code	Type	Course	L T P	Cr
MA620	FC	Linear Algebra and Numerical Methods	3 0 0	3
PE611	FC	Power Converters I	3 0 1	4
PE621	SC	Electrical Machine Analysis	3 0 0	3
PE622	SC	Modern Control Theory	3 0 0	3
PE623	SC	Soft Computing	3 0 1	4
PE624	SC	Simulation Laboratory	0 0 1	1
HU601	HU	Cultural Education*		P/F
			Credits	18

* Non-Credit Course

Second Semester

Course Code	Type	Course	L T P	Cr
PE612	FC	Digital Signal Processing	3 0 1	4
PE613	FC	Power Converters II	3 0 1	4
PE625	SC	Electric Drives and Control	3 0 0	3
PE626	SC	Digital Signal Processors	3 0 1	4
	E	Elective I	3 0 0	3
EN600	HU	Technical Writing*		P/F
			Credits	18

* Non-Credit Course

Third Semester

Course Code	Type	Course	L T P	Cr
PE614	FC	FPGA based System Design	3 0 1	4
	E	Elective II	3 0 0	3
PE627	SC	Electric Drives and Control Laboratory	0 0 1	1
PE799	P	Dissertation		8
			Credits	16

Fourth Semester

Course Code	Type	Course	L T P	Cr
PE799	P	Dissertation		14
			Credits	14

Total Credits: 66

List of Courses

Foundation Core

Course Code	Course	L T P	Cr
MA620	Linear Algebra and Numerical Methods	3 0 0	3
PE611	Power Converters I	3 0 1	4
PE612	Digital Signal Processing	3 0 1	4
PE613	Power Converters II	3 0 1	4
PE614	FPGA based System Design	3 0 1	4

Subject Core

Course Code	Course	L T P	Cr
PE621	Electrical Machine Analysis	3 0 0	3
PE622	Modern Control Theory	3 0 0	3
PE623	Soft Computing	3 0 1	4
PE624	Simulation Laboratory	0 0 1	1
PE625	Electric Drives and Control	3 0 0	3
PE626	Digital Signal Processors	3 0 1	4
PE627	Electric Drives and Control Laboratory	0 0 1	1

Electives

Course Code	Course	L T P	Cr
PE701	Flexible AC Transmission Systems	3 0 0	3
PE702	Renewable Energy Technologies	3 0 0	3
PE703	Special Electric Machines	3 0 0	3
MA701	Optimization Theory	2 1 0	3
PE705	Electric Power Quality Improvement	3 0 0	3
PE706	Energy Conservation and Management	3 0 0	3
PE707	Programmable Logic Controllers	3 0 0	3
PE708	Power System Operation and Control	3 0 0	3
PE709	Design for reliability	3 0 0	3
PE710	Electromagnetic Interference and Compatibility	3 0 0	3
PE711	Electrical Machine Analysis Using Finite Element Analysis	3 0 0	3
RE709	Smart Grid	3 0 0	3

Project Work

Course Code	Course	L T P	Cr
PE799	Dissertation		22

Vector Spaces: General vector spaces - Sub spaces - Linear independence - Basis – Dimension- Row space, Column space and Null Space – Rank and Nullity.

Inner Product Spaces: Inner products - Orthogonality - Orthogonal basis - Orthogonal complements - Projection on subspace - Gram Schmidt Process - QR- Decomposition – Best approximation - Least square – Least squares fitting to data - Change of basis.

Linear Transformations: Linear transformation – General linear transformation - Kernel and range of a linear transformation - Inverse Linear Transformation - Matrices of general linear transformation- Nilpotent transformations - Similarity - Diagonalisation and its applications - Jordan form and rational canonical form - Positive definite matrices - Matrix norm and condition number.

Numerical methods: Solution of systems of equations – iterative methods, method of determining Eigen values and Eigen vectors by Power method. Numerical solution of partial differential equations – Elliptic, parabolic and hyperbolic equations.

TEXT BOOKS / REFERENCES:

1. Howard Anton and Chris Dorres, “*Elementary Linear Algebra*”, Tenth Edition, John Wiley & Sons, 2010.
2. Gilbert Strang, “*Linear Algebra and Its Applications*”, Fourth Edition, Cengage, 2006.
3. Kenneth Hoffmann and Ray Kunze, *Linear Algebra*, Second Edition, Prentice Hall, 1971.
4. Curtis F. Gerald and Patrick O. Wheatley, “*Applied Numerical analysis*”, Fifth Edition, Addison Wesley, 2002.

Power semiconductor switches: ratings, characteristics, power loss and temperature rise calculations, and control (BJT, MOSFETS, IGBT, Thyristors, IPM, IGC). AC voltage controllers- Line commutated, uncontrolled and phase controlled converters: Performance factors, Line notching and distortion. Twelve pulse converters, Cyclo-converters, Matrix Converters. Voltage source inverters: single phase and three phase inverters, zero voltage switching clamped voltage inverters, Sinusoidal PWM and Space vector PWM. Multi-stepped inverters, Multilevel inverters and resonant inverters. UPS. Demonstration designs.

TEXT BOOKS/ REFERENCES:

1. Ned Mohan, Tore M. Undeland and William P. Robbins, “*Power Electronics, Converters, Applications and Design*”, Third Edition, John Wiley & Sons Inc., 2006.
2. Muhammad H. Rashid, “*Power Electronics, Circuits, Devices and Applications*”, Third Edition, Prentice Hall of India Private Limited, 2004.
3. John G. Kassakian, Martin F. Schlecht and George C. Verghese, “*Principles of Power Electronics*”, Addison Wesley Publishing Company, 1991.
4. Bimal K Bose, “*Modern Power Electronics and AC Drives*”, Prentice – Hall of India Private Limited, 2002.
5. Barry W Williams, “*Principles and Elements of Power Electronics Devices, Drivers, Applications, and Passive Components*”, Barry W Williams, 2006.

Principles of electromagnetic energy conversion: General expression of stored magnetic energy, co-energy and force/torque, example using single and doubly excited system; Calculation of air gap mmf and per phase machine inductance using physical machine data; Voltage and torque equation of dc machine; three phase symmetrical induction machine and salient pole synchronous machines in phase variable form. Introduction to reference frame theory: static and rotating reference frames, transformation relationships. Application of reference frame theory to three phase symmetrical induction and synchronous machines, dynamic direct and quadrature axis model in arbitrarily rotating reference frames, voltage and torque equations, derivation of steady state phasor relationship from dynamic model, generalized theory of rotating electrical machine and Kron's primitive machine; Determination of synchronous machine dynamic equivalent circuit parameters: standard and derived machine time constants, frequency response test; Analysis and dynamic modeling of two phase asymmetrical induction machine and single phase induction machine; Permanent magnet synchronous machine, Brush less dc machine.

TEXT BOOKS/ REFERENCES:

1. P.C.Krause, "*Analysis of Electric Machines and Drive Systems*", Wiley International, 2002.
2. Jones C.V, "*The Unified Theory of Electrical Machines*", Butter Worth Publications, 1968.
3. A.E. Fitzgerald and Charles Kingsley, "*Electric Machinery*", McGraw Hill Book Company, 1986.
4. B. Adkins, "*Generalized Machine Theory*", McGraw Hill Book Company, 1964.
5. Bimbhra P S, "*Electrical Machinery*", Khanna Publishers, 1995.

State Variable Analysis and Design: Introduction, concept of state, state variables and state model, state modeling of linear systems, linearization of state equations. State Space representation using physical variables, Phase variables and Canonical variables. Derivation of transfer function from state model, diagonalization, Eigen values, Eigen vectors, generalized Eigen vectors. Solution of state equation, state transition matrix and its properties, computation using Laplace transformation, power series method, Cayley-Hamilton method, concept of controllability and observability, methods of determining the same.

Pole Placement Techniques: Stability improvements by state feedback, necessary and sufficient conditions for arbitrary pole placement, state regulator design, and design of state observer, Controllers- P, PI, PID. Non-linear systems: Introduction, behavior of non-linear system, common physical non linearity-saturation, friction, backlash, dead zone, relay, multi- variable non-linearity. Phase plane method, singular points, stability of nonlinear system, limit cycles, construction of phase trajectories. Liapunov stability criteria, Liapunov functions, direct method of Liapunov and the linear system, Hurwitz criterion and Liapunov's direct method, construction of Liapunov functions for nonlinear system.

TEXT BOOKS/ REFERENCES:

1. Ogata, "*Modern Control Engineering*". Fifth Edition, Prentice Hall, 2009.
2. Franklin and Powell, "*Feedback Control of Dynamics Systems*". Fourth Edition, Prentice Hall, 2002.
3. Joseph DiStefano III, Allen J. Stubberud and Ivan J. Williams "*Feedback and Control Systems*". Schaum's outline Series, McGraw-Hill, 1967.

4. David G. Luenberger, “*Introduction to Dynamic Systems: Theory, Models, and Applications*”, Wiley, 1979.
5. Richard C. Dorf and Robert H. Bishop, “*Modern Control Systems*”, Eleventh Edition Prentice Hall, 2008.

PE623

SOFT COMPUTING

3-0-1-4

Fuzzy Logic (FL) – Membership Functions – Fuzzifications and Defuzzifications – Fuzzy Relations – TSK - Fuzzy Modeling -- Neural Networks (NN) – Supervised and Unsupervised Learning – Hebbian Learning – BPN -- Hopfield – RBF Networks – Kohonen Self Organizing Networks – Learning Vector Quantization — Adaptive Resonance Theory – Genetic Algorithms (GA) – Standard GA -- Introduction to Chaos Theory -- Rough Set Theory – Feature Extraction – Dimensionality Reduction – Discernability Matrix -- Introduction to Support Vector Machines – Classification and Regression – Concept of kernels -- Typical Applications Integrating Various Soft Computing Tools.

TEXT BOOKS / REFERENCES:

1. Timothy Ross, “*Fuzzy Logic with Engineering Applications*” , Second Edition, John Wiley and Sons, 2004.
2. Simon Haykin, “*Neural Networks and Learning Machines,*” Third Edition, Pearson Education, 2009.
3. K.F. Man, K.S. Tang and S. Kwong, “*Genetic Algorithms: Concepts and Applications*”, IEEE Transactions Industrial Electronics, Vol-3, 1996.
4. Thomas S. Parker and Leon O Chua, “*CHAOS : A Tutorial for Engineers*”, Proceedings IEEE, Vol-75 , No.8, 1987.
5. Jan Komorowski, Lech Polkowski and Andrzej Skowron, “*Rough Sets: A Tutorial*”, <http://Folli.Loria.Fr/Cds/1999/Library/Pdf/Skowron.Pdf>

PE624

SIMULATION LABORATORY

0-0-1-1

Matlab/Simulink, OrCAD PSpice, PSCAD/EMTDC and EMTP for Power Electronics, Drives and Control applications.

PE612

DIGITAL SIGNAL PROCESSING

3-0-1-4

Spectrum Analysis: Frequency and time domain analysis, Sampling and aliasing. Discrete Fourier Transform. Fast Fourier Transform. FFT. Digital Filters: IIR Filters, Bilinear transformation. FIR filters. Random Processes and Adaptive Signal Processing, Wiener Filters, Kalman filters. Multirate Digital Signal Processing. Applications of Digital Signal Processing.

TEXT BOOKS/ REFERENCES:

1. Proakis J. G. and Manolakis D. G., “*Digital Signal Processing: Principles, Algorithms, and Applications*”, Prentice Hall, 1996.
2. Simon Haykin, “*Adaptive Filter Theory*”, Prentice Hall, 1997.
3. Ifeachor E. C. and Jervis B. W., “*Digital Signal Processing: A Practical Approach*”, Addison Wesley, 1993.
4. Vaidyanathan P. P, “*Multirate Systems and Filter Banks*”, Prentice Hall, 1993.

5. Mitra S.K., “*Digital Signal Processing, A Computer-Based Approach*”, McGraw Hill, 2002.

PE613

POWER CONVERTERS II

3-0-1-4

DC-DC converters: buck, boost, buck-boost, SEPIC, fly-back, forward, push-pull, half bridge, full bridge converters, soft switched bidirectional DC-DC converters. Design of high frequency transformers and inductors-Drive and protection of switching power devices - voltage mode control and current mode control, modeling of the converters, Compensation of the feedback system for dc-dc converters. Single phase AC to DC converters with high power factor- Control of switch-mode converter for utility interface. Boost derived isolated DC-DC Converters. Typical specifications of power converters, design of power circuit to meet the specifications. EMI and Layout Fundamentals for switched mode circuits. Demonstration designs.

TEXT BOOKS/ REFERENCES:

1. Ned Mohan, Tore M. Undeland and William P. Robbins, “*Power Electronics, Converters, Applications and Design*”, Third Edition, John Wiley & Sons Inc., 2006.
2. Robert W Erickson and Dragan Maksimovic, “*Fundamentals of Power Electronics*”, Springer International, 2001.
3. Daniel W Hart, “*Power Electronics*”, Tata Mc Graw Hill, 2011.
4. John G. Kassakian, Martin F. Schlecht and George C. Verghese, “*Principles of Power Electronics*”, Addison Wesley Publishing Company, 1991.
5. V. Ramanarayanan, “*Course Material on Switched Mode Power Conversion*”, Department of Electrical Engineering, Indian Institute of Science, Bangalore.
<http://minchu.ee.iisc.ernet.in/new/people/faculty/vr/book.pdf>

PE625

ELECTRIC DRIVES AND CONTROL

3-0-0-3

Elementary principles of mechanics, dynamics of drives, steady state characteristics of motors and loads, stability of electric drives, four quadrant operations.

Separately excited DC motor drive, mathematical model, armature and field control, dynamic behavior with constant flux, control of separately excited motor in armature control and field weakening region, control with line commutated converter, dynamic model of line commutated converter, drive with chopper control.

Three phase induction motor, steady state operation with sinusoidal voltage, v/f control, vector control of Induction machine, space vector concepts, direct torque control, speed control of wound rotor induction machine, static Scherbius and Kramer drive.

Control of wound field synchronous machine, permanent magnet synchronous machine, switched reluctance motor and brush-less DC machine.

TEXT BOOKS/REFERENCES:

1. Werner Leonhard, “*Control of Electrical Drives*”, Third Edition, Springer International Edition, 2006.
2. Bimal K. Bose, “*Power Electronics and Variable Frequency Drives*”, IEEE Press, 2002.
3. Krishnan R, “*Electric Motor Drives Modeling, Analysis and Control*”, Prentice Hall of India, 2001.
4. Dr. Joseph Vithyathil, “*Power Electronics – Principles and Applications*”, Tata McGraw Hill Education Pvt. Ltd., 2010

5. Gopal K. Dubey, “*Fundamentals of Electric Drives*”, Second Edition, Narosa Publishing House, 2001.

PE626

DIGITAL SIGNAL PROCESSORS

3-0-1-4

Introduction to Microprocessors – Microcontrollers – Digital signal controllers (DSC) and Digital Signal Processors - Basic building blocks of a typical DSP processor – Hardware Multiplier – Barrel Shifter – MAC unit – Modified Harvard architecture – RISC Versus CISC - Pipelining. Architecture of dsPIC30F3011 DSC – Instruction set – Addressing modes – Assembly language and C programming – MPLAB ASM30 Assembler and C30 Compiler - Peripherals – Ports – Timers – Input capture – Output compare - ADC – MCPWM – QEI – UART. Architecture of TMS320C2806x Piccolo DSP – Instruction set – Programming – Code Composer Studio. Application development - Implementation of PI controller, Filter algorithms, Clark and Park transformations, SPWM and SVPWM, PLL and Unit sine wave generation.

TEXT BOOKS/REFERENCES:

1. dsPIC30F Family Reference Manual.
2. dsPIC30F Programmers Reference Manual.
3. TMS320C2806x Piccolo Technical Reference Manual.
4. Toliyat, Hamid A. and Steven Campbell, “*DSP-Based Eelectromechanical Motion Control*”, CRC Press, 2003.
5. Application notes on DSP based Motor control: www.ti.com and www.microchip.com

EN600

TECHNICAL WRITING

P/F

Technical terms- Definitions- extended definitions- grammar checks- error detection- punctuation- spelling and number rules - tone and style- pre-writing techniques - Online and offline library resources- citing references – plagiarism - Graphical representation - documentation styles- instruction manuals- information brochures- research papers, proposals – reports (dissertation, project reports etc.) - Oral presentations.

TEXTBOOKS/REFERENCES:

1. Hirish, Herbert L. “*Essential Communication Strategies for Scientists, Engineers and Technology Professionals*”. Second Edition. New York: IEEE press, 2002.
2. Anderson, Paul V. “*Technical Communication: A Reader-Centred Approach*”. VI Edition. Cengage Learning India Pvt. Ltd., New Delhi, Reprint, 2010.
3. Strunk, William Jr. and White, E.B. “*The Elements of Style*” New York. Alliyon and Bacon, 1999.

PE614

FPGA BASED SYSTEM DESIGN

3-0-1-4

HDL – Role of HDL - VHDL for Design Synthesis - Design Flow – Programmable logic: Simple PLDs, CPLDs, FPGA VHDL - Entities and Architectures - A Simple Design - Design Entities – VHDL elements - Data flow – behavioural – structural modeling - Creating Combinational and Synchronous Logic - Designing FIFO - Test Benches - State Machine Designs - Design Examples - Memory Controller - Mealy State Machines - Design Considerations - Hierarchy in Large Designs - Functions and Procedures – Subprograms

General principles of circuit synthesis - Synthesis and Design Implementation - Synthesis and Fitting CPLDs, FPGAs - Optimizing Data paths – Pipelining - Resource Sharing - Creating Test Benches – Implementation technology – PLD’s, Custom Chips, Standard Cell and Gate arrays – FPGA Architectures – SRAM based FPGAs – Permanently programmed FPGAs – Circuit design of FPGA fabrics – Architecture of FPGA fabrics – Logic Implementation of FPGAs - Physical design for FPGAs

TEXT BOOKS / REFERENCES:

1. Kevin Skahill, “*VHDL for Programmable Logic*”, Pearson Education, 1996.
2. Stephen Brown and Zvonko Vranesic, “*Fundamental of Digital Logic with VHDL Design*”, Second Edition, McGraw Hill, 2000.
3. Douglas L Perry, “*VHDL Programming by Example*”, Fourth Edition, Tata Mc Graw Hill, 2002.
4. Wayne Wolf, “*FPGA-Based System Design*”, Prentice Hall India Pvt. Ltd., 2004.
5. Samir Palnitkar, “*Verilog HDL - A Guide to Digital Design and Synthesis*”, Second Edition, Pearson Education, 2003.

PE627 ELECTRIC DRIVES AND CONTROL LABORATORY 0-0-1-1

D.C. Machine Modeling, Phase-controlled D.C. Motor Drives - DC/DC Chopper Controlled DC Motor Drives - Induction Motor Drives - Stepper motor drive. Servo drive.

PE701 FLEXIBLE AC TRANSMISSION SYSTEMS 3-0-0-3

Transmission system: Transmission interconnections, Flow of power in an AC system, Loading capability, Power flow and dynamic stability, Principle of Compensators- FACTS concept and types of FACTS controllers, IEEE definitions.

Shunt compensators: Variable impedance (TCR, TSC, FC-TCR, TSC-TCR), Switched converter (STATCOM) and Hybrid shunt compensators. Control schemes for compensators

Series compensators: Variable impedance (GCSC, TSSC, TCSC), Static Synchronous Series Compensators (SSSC). Control schemes for compensators.

Static voltage and phase angle regulators: Concepts of power flow control, Transient stability, Power oscillation damping, Thyristor-controlled, Switched converter and Hybrid regulators. Applications.

Unified power flow controller (UPFC), Interline power flow controller (IPFC), NGH-SSR damper, Thyristor-controlled braking resistor (TCBR). Case studies.

Overview of High Voltage DC Transmission.

TEXT BOOKS/ REFERENCES:

1. Narain G. Hingorani and Laszlo Gyugyi, “*Understanding FACTS – Concepts and Technology of Flexible AC Transmission Systems*”, IEEE Power Engineering Society, 2001.
2. T.J.E.Miller, “*Reactive Power Control in Electric Systems*”, John Wiley & Sons, 1982.
3. R.Mohan, Mathur and Rajiv. K. Varma, “*Thyristor Based FACTS Controller for Electrical Transmission System, IEEE Series on Power Engineering*”, Wiley Interscience, 2002.
4. Padiyar K. R, “*FACTS Controllers in Power Transmission and Distribution*”, New Age Publishers, 2007.

Renewable energy sources: Renewable energy utilization in ancient times; classification of RE technologies – stand alone, hybrid and grid-connected; Recent developments in renewable energy sector – global and national energy policies

Wind energy – Global and local winds, resource assessment, wind regime modeling – Weibull parameters; WEG technologies for grid connection.

Solar energy – Solar radiation and measurements; PV Cell – principle, types and construction; Modeling of PV cell; Maximum power tracking; SPV systems – stand alone and grid-connected.

Other renewable energy technologies: Biomass – gasifiers; Small hydro – resource assessment, selection of turbines, Electronic load controller; Wave, Tidal, Ocean thermal and Geothermal energy systems – principles and technologies; Energy storage systems.

TEXT BOOKS / REFERENCES:

1. Thomas B Johansson, “*Renewable Energy: Sources for Fuels and Electricity*”, Island Press, Washington, 1993.
2. John W Twidell and A D Weir, “*Renewable Energy Resources*”, ELBS, 1986.
3. N K Bansal, M Kleemann and M Mellis, “*Renewable Energy Resources and Conversion Technology*”, Tata McGraw Hill, 1990.
4. S N Bhadra, D Kasta and S Banerji, “*Wind Electrical Systems*”, Oxford University Press, 2005.

Stepper motor - Driver circuit- Unipolar drive circuit - Bipolar drive circuit - Micro processor based control. Switched Reluctance motor (SRM) - Power converters for SRM - closed loop control - Position sensing for rotor – Different methods of rotor positioning - Micro processor based control - Permanent Magnet Synchronous Motor (PMSM) - Electronic drive topology Converters and Controllers - Control of PMSM - Sensored control and Sensorless control - Scalar based control (Volt/Hz) - Vector based control - Field Oriented and Direct Torque control - Brushless DC motor (BLDC) - Driver circuit - Controller for BLDC - PID controller - Fuzzy controller - ANN controller.

TEXT BOOKS / REFERENCES:

1. S.A. Nasar, I. Boldea and L.E. Unnewehr, “*Permanent Magnet, Reluctance and Self-Synchronous Motors*”, CRC Press Inc., 1993.
2. K Venkataratnam, “*Special Electrical Machines*”, University Press, 2008.
3. Timothy John Eastham Miller, “*Brushless Permanent-Magnet and Reluctance Motor Drives*”, Clarendon Press, 1989.
4. Jacek F. Gieras, “*Permanent Magnet Motor Technology*”, Third Edition, CRC Press Taylor and Francis Group, 2005.
5. Thimothy L. Skvarenina, “*The Power Electronics Handbook*”, CRC press, 2001.

Review of Linear Algebra: Linear programming models: Simplex search — sensitivity analysis – artificial starting solutions - duality and sensitivity in linear programming. Single variable optimization: Analytical method: Optimality criteria. Single variable non-linear problems using

derivatives. Computational Methods: Non-linear one-dimensional methods – single variable optimization algorithms – optimization criteria – bracketing methods – region elimination methods – point estimation method – gradient based methods. Multivariable optimization: Analytical method: Positive and negative definite, Hessian matrix, Optimality criteria. Multivariable non-linear problems using partial derivatives. Computational Methods: Non-linear unconstrained methods - multivariate optimization algorithms – optimality criteria – unidirectional search – direct search methods – gradient based methods. Constrained optimization: Non-linear constrained methods – Kuhn-tucker conditions – transformation methods – direct search for constrained minimization – feasible direction method

TEXT BOOKS/ REFERENCES:

1. Kalyanmoy Deb, “*Optimization for Engineering Design: Algorithms and Examples*”, Prentice Hall, 2002.
2. Ronald L. Rardin, “*Optimization in Operations Research*”, Prentice Hall, New Jersey, 1998.
3. Singiresu S. Rao, “*Engineering Optimization: Theory and Practice*”, Third Edition, New Age Publishers, 2003.
4. Hamady A. Taha, “*Operations Research*”, Sixth Edition, Tata McGraw Hill, 2004.

PE705

ELECTRIC POWER QUALITY IMPROVEMENT

3-0-0-3

Review of power quality issues-Voltage sags and swells, interruptions, transients, notches, unbalance, distortions, fluctuations and flicker. IEEE Recommended Practices and Requirements for Harmonic Control in Electric Power Systems 519-1992, Recommended Practices for Individual Consumers – Recommended Practices for Utilities - Causes and effects of power quality issues, Measurements. Harmonic studies: Circuit analysis and power assessment under non-sinusoidal conditions- Symmetrical components- Harmonic propagation studies in large network- FFT Analysis.

Power Quality Improvement techniques: Passive filters – Review - Harmonic and Reactive power compensation – Design, Active Filters – Review - Active filter control schemes/algorithms- Time domain and frequency domain - Instantaneous reactive power theory (IRPT) algorithm, Synchronous Detection (SD) algorithm, DC Bus voltage algorithm, Synchronous reference frame (SRF) algorithm, ICOS ϕ algorithm, AI based control algorithms, Analog/digital implementation - Case studies. Hybrid Filters –Review – Design -Applications - Estimation of rate/cost reduction with hybrid filters. Review of single-phase and three-phase improved power quality converters - Applications. Custom power parks -Custom power devices and Applications.

TEXT BOOKS/ REFERENCES:

1. J.Arillaga, N.R.Watson and S.Chen, “*Power System Harmonics*”, John Wiley & Sons, England, 2003.
2. Math J.Bollen, “*Understanding Power Quality Problems-Voltage Sags and Interruptions*”, John Wiley & Sons, New Jersey, 2000.
3. Enrique Acha and Manuel Madrigal, “*Power Systems Harmonics-Computer Modeling and Analysis*”, John Wiley and Sons Ltd., 2001.
4. George J. Wakileh, “*Power Systems Harmonics-Fundamentals, Analysis and Filter Design*”, Springer-Verlag, New York, 2001.
5. Ewald and Mohammad Masoum, “*Power Quality in Power Systems and Electrical Machines*”, Elseveir Academic Press, 2008.

Historical development of commercial energy supply: Commercial energy in ancient times, Renewable Energy utilization in ancient times, Industrial revolution, Growth of fossil fuel systems, Emergence of nuclear power, Realization of environmental concerns, Developments in Renewable Energy Sector; Concept of Energy Efficiency and Clean Production.

Energy conservation on demand side: Efficient Lighting; Energy Efficiency in motors, pumps and fans. Power quality issues related to Energy Efficient Technologies.

Energy Economics: Time value of money - Present Worth and Future Worth Economic performance indices: Payback - Simple and Discounted, Net Present Value, Internal Rate of Return, Benefit to Cost Ratio, E/D ratio, Life cycle/levelised cost.

Energy Management in Electrical Power Systems: Supply-demand gap on electric power grid: causes and remedial measures. Energy trading; Demand Response; Microgrids and Smart grid.

Energy Management and Audit: Functions and methodologies of preliminary as well as detailed energy audits; Pre-audit, audit and post-audit measures Instruments for energy audit, Energy Conservation Practice – Case Studies.

TEXT BOOKS / REFERENCES:

1. Hamies, “*Energy Auditing and Conservation; Methods, Measurements, Management & Case study*”, Hemisphere Publishers, Washington, 1980.
2. C.W. Gellings and J.H. Chamberlin, “*Demand-Side Management Planning*”, Fairmont Press, 1993.
3. Wayne C Turner, “*Energy Management Handbook*”, The Fairmount Press, 2006.
4. Bureau of Energy Efficiency Study material for Energy Managers and Auditors Examination: Paper I to IV, www.energymanagertraining.com
5. S. Pabla, “*Electric Power Systems Planning*”, Macmillan India Ltd., 1998.

Introduction to PLC-Ladder diagram-relay logic-digital and analog PLC interface-input and output modules-PLC processors-processor data organization- basic relay instruction-timer and counter instruction-sequencer instruction-programme flow instruction- case studies-motor control.

TEXT BOOKS / REFERENCES:

1. Dunning Carry, “*Introduction to Programmable Controllers*”, Third Edition, Thomson Delmar Learning, 2006.
2. John R. Hackworth and Frederick D, “*Programmable Logic Controllers: Programming Methods and Applications*”, Pearson Education Inc., 2004.
3. Bolton W, “*Programmable Logic Controllers*”, Fifth Edition, Elsevier, 2009.
4. John W Webb and Ronald A Reis, “*Programmable Logic Controllers: Principles and Applications*”, Fifth Edition, PHI learning Pvt. Ltd., 2009.
5. Frank D.P., “*Programmable Logic Controllers*”, Second Edition, Tata Mc Graw Hill Publishing Company Limited, 1997.

Introduction- System load Variation: System load characteristics, Load curve- weekly and annual duration curve, load factor, diversity factor. Overview of system control: Governor

control, LFC, AVR. Linear Models of Synchronous machines- Transient stability- Dynamic Stability. Real power- frequency control: Need for voltage and frequency regulation in power system, basic P-f and Q-V control loops. Fundamentals of speed governing systems and modeling, LFC of Single area and two area systems. Simulink models of single and two area system -Power System Stabilizers. Reactive power – Voltage control: Typical excitation system, static and dynamic analysis, effect of generator loading, static shunt capacitor/reactor VAR compensator, synchronous condenser, tap changing transformer, Static VAR system, modeling, system level voltage control. Economic Dispatch: Incremental cost curve, co-ordination equations with loss and without losses- solution by iteration method. Base point and participation factors. Economic controller added to LFC control.

TEXT BOOKS/ REFERENCES:

1. Olle.I.Elgerd, “*Electric Energy Systems Theory- An Introduction*”, Tata Mc Graw Hill Publishing company Ltd., New Delhi, 2004.
2. D. P. Kothari and I. J. Nagrath, “*Modern Power System Analysis*”, Tata Mc Graw Hill Publishing company Ltd., New Delhi, 2005.
3. Allen.J. Wood and Bruce.F.Wollenberg, “*Power Generation Operation and Control*”, John Wiley and Sons, 1984.
4. L.K.Kirchmayer, “*Economic Operation of Power System*”, John Wiley and Sons, 1953.

PE709

DESIGN FOR RELIABILITY

3-0-0-3

Review of Probability theory – Introduction to the concepts of Reliability – Nature of Reliability problems in Electronic equipment – Reliability modeling – Availability and maintainability concepts – Designing for Reliability – Fault Analysis techniques – Reliability predictions – Worst case design and component de-rating – software Reliability.

TEXT BOOKS / REFERENCES:

1. Fuqua, “*Reliability Engineering for Electronic Design*”, Marcel Dekker, 1988.
2. Patrick DTO’Connor, “*Practical Reliability Engineering*”, John Wiley & Sons, 1985.
3. MIL Handbook-338 – “*Reliability of Electronic Equipment*”.
4. L.Umanand, “*Power Electronics Essentials and Applications*”, Wiley India Pvt. Ltd., 2009.

PE710 ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY 3-0-0-3

Problems of EMI and Sources – ESD – High Frequency behavior of Electrical Components-EMI in Power Electronic Equipments – EMI induced failure mechanism in PE Equipment – Susceptibility aspects of power Electronic and Digital Equipments – Noise Suppression in Circuits – Reduction Techniques for Internal EMI – EMI reduction techniques – Grounding, Shielding and Bonding, use of cables connectors components, EMI filter selection, Filter design, Testing for susceptibility to power line disturbances, transient susceptibility and analysis methods, EMC standards and test equipments.

TEXT BOOKS/REFERENCES:

1. Laszio Tihanyi, “*EMC in Power Electronics*”, IEEE Press, 1995.
2. V.Prasad, “*Engineering Electromagnetic Compatibility*”, IEEE Press, 2001.
3. Henry W.Ott, “*Noise Reduction Techniques in Electronic Systems*”, Second Edition, John Wiley and Sons Ltd., 1988.

4. Rajiv Thottappillil, Lecture Notes on EMC, KTH University.

PE711

**ELECTRICAL MACHINE ANALYSIS USING
FINITE ELEMENT ANALYSIS**

3-0-0-3

Review of Electromagnetic theory, basic principles of finite element method, applications of finite element method to two dimensional fields, linear interpolation, variational method, description of electromagnetic fields, analysis procedure using finite element method, reduction of field problem to a two dimensional problem, boundary conditions, drawing flux line, magnetic energy and co-energy, magnetic forces, determination of electrical parameters.

Cylindrical magnetic devices, analytical study of magnetic devices, finite element analysis, single phase transformer, computation of no load inductance, determination of leakage inductance, algorithm for the construction of magnetizing characteristics of a transformer.

Single phase variable reactance, computation of reactance.

TEXT BOOKS /REFERENCES:

1. Nicola Bianchi, “*Electrical Machine Analysis Using Finite Elements*”, CRC Press, 2005.
2. Cheng D K, “*Fundamentals of Engineering Electromagnetic*”, Addison Wesley, 1993.
3. Reece A and Preston T, “*Finite Element Method in Electric Power Engineering*”, Oxford University Press, UK, 2000.
4. Fitzgerald A E, Kingsley C, (Jr), and Umans S D, “*Electric Machinery*”, McGraw Hill, New York, 1983.
5. Nagrath I.J and Kothari D.P, “*Electric Machines*”, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1985.

RE709

SMART GRID

3-0-0-3

Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Functions of Smart Grid, Opportunities & Barriers of Smart Grid. Today’s grid versus smart grid. Present development & International policies in Smart Grid. Smart Grid – Overview and stakeholders. Performance analysis tools for smart grid, Stability analysis tools for smart grid. Smart Grid Technologies: Communication Technologies for Smart Grid, Interoperability and connectivity, Layered Architecture and Protocols, Standards for Information Exchange. Information Security in smart grid - Encryption and decryption, Authentication, Digital Signatures, Cyber Security standards. Smart Meters, Demand response. Distribution Side automation and Transmission side automation – WAMS. Power electronics in Smart grid. Renewable Energy and Storage Technologies – Distributed generation and storage. Solar, Wind, Pumped Hydro, PHEVs. Market Model for smart grid. Regulation and standardization of smart grid.

TEXT BOOKS/ REFERENCES:

1. James Momoh, “*Smart Grid: Fundamentals of Design and Analysis*”, Wiley-IEEE Press, March 2012.
2. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu and Akihiko Yokoyama, “*Smart Grid: Technology and Applications*”, Wiley, February 2012.
3. Nouredine Hadjsaïd and Jean-Claude Sabonnadière, “*Smart Grids*”, Wiley-ISTE, May 2012.
4. Ali Keyhani and Muhammad Marwali, “*Smart Power Grids 2011*”, Springer, 2011.

Each student should select and work on a topic related to his/her field of specialization during summer of second semester under the supervision of a faculty member. By the end of the third semester he/she must prepare a report in the approved format and present it. During fourth semester each student should work further on the topic of the minor project or a new topic under the supervision of a faculty member. By the end of fourth semester the student has to prepare a report in the approved format and present it.