M.Tech.(PED), R17 Course Structure (Choice Based Credit System)

I SEMESTER

S. No	Course Code	Course Title	Contact hours/week				Credits	Scheme of Valuation		
			L	T	P	Total		CIE	SEE	Total
1	17PE01	Computational Mathematics	2	2	-	4	3	40	60	100
2	17PE02	Analysis of Power Converters	2	2	-	4	3	40	60	100
3	17PE03	Control of Motor Drives-I	2	2	-	4	3	40	60	100
4	PE-I	Programme Elective -I	2	2	-	4	3	40	60	100
5	PE-II	Programme Elective -II	2	2	-	4	3	40	60	100
6	17PE60	Power Converter and Drives-I Lab	-	-	2	2	1	40	60	100
7	17PE61	Simulation of Power converters and Drives-I Lab	-	-	2	2	1	40	60	100
8	17PE50	Technical Seminar	-	-	2	2	1	100	--	100
10	17PE90	**Add-on-Course-1** Advanced Power Semiconductor Devices and their Protection	3	-	-	3	3	40	60	100
		Total	**10/ 13**	**10**	**6**	**26/ 29***	**18/ 21***	**380/ 420***	**420/ 480***	**800/ 900***

***With inclusion of Add on course**

II SEMESTER

S. No	Course Code	Course Title	Contact hours/week				Credits	Scheme of Valuation		
			L	T	P	Total		CIE	SEE	Total
1	17PE10	Modern Control Theory	2	2	-	4	3	40	60	100
2	17PE11	Switched Mode Power Conversion	2	2	-	4	3	40	60	100
3	17PE12	Control of Motor Drives-II	2	2	-	4	3	40	60	100
4	PE-III	Programme Elective -III	2	2	-	4	3	40	60	100
5	PE-IV	Programme Elective -IV	2	2	-	4	3	40	60	100
6	17PE62	Power Converter and Drives-II Lab	-	-	2	2	1	40	60	100
7	17PE63	Simulation of Power Converters and Drives –II Lab	-	-	2	2	1	40	60	100
8	17PE51	Mini Project	-	-	2	2	1	100	--	100
10	17PE91	**Add-on-Course-2** Integration of Renewable Sources	3	-	-	3	3	40	60	100
		Total	**10/ 13***	**10**	**6**	**26/ 29***	**18/ 21***	**380/ 420***	**420/ 480***	**800/ 900***

***With inclusion of Add on course**

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III SEMESTER

S. No	Course Code	Course Title	Contact hours/week				Credits	Scheme of Valuation		
			L	T	P	Total		CIE	SEE	Total
1	PE-V	Programme Elective -V	2	2	-	4	3	40	60	100
2	PE-VI	Programme Elective -VI	2	2	-	4	3	40	60	100
3	17PE52	Internship	-	-	-	-	2	100	--	100
4	17PE53	Project Work (Phase-I)	-	-	20	20	10	40	60	100
		Total	**0/ 2/ 4**	**0/ 2/ 4**	**20**	**20/ 24/ 28**	**12/15/18**	**140/ 180/ 220**	**60/ 120/ 180**	**200/ 300/ 400**

IV SEMESTER

S.No	Course Code	Course Title	Contact hours/week				Credits	Scheme of Valuation		
			L	T	P	Total		CIE	SEE	Total
1	17PE54	Project Work (Phase-II)	-	-	32	32	16	40	60	100
2	17PE55	Comprehensive Viva Voce	-	-	4	4	2	100	--	100
		Total	**-**	**-**	**36**	**36**	**18**	**140**	**60**	**200**

List of courses for Programme Elective- I & II

S.No	Course Code	Course Title
1	17PE04	Optimization Techniques in Electrical Engineering
2	17PE05	HVDC and FACTS
3	17PE06	Energy Auditing and Management
4	17PE07	Machine Modeling and Analysis
5	17PE08	Analysis of Special Electrical Machines
6	17PE09	Modeling and Simulation of Power Electronic Systems

Note: Students are required to choose any two courses as Programme Elective- I & II

List of courses for Programme Elective- III& IV

S.No	Course Code	Course Title
1	17PE13	Power Quality Engineering
2	17PE14	Hybrid Electrical Vehicles
3	17PE15	Reactive Power Management
4	17PE16	DSP and FPGA Processors
5	17PE17	Applications of Artificial Intelligence Techniques
6	17PE18	Advanced Micro processors and Micro controllers

Note: Students are required to choose any two courses as Programme Elective- III & IV.

List of courses for Programme Elective- V & VI

S.No	Course Code	Course Title
1	17PE19	Industrial Electronics
2	17PE20	Micro and Smart Grids
3	17PE21	Drive Systems in Electric Traction
4	17PE22	Emerging Trends in Power Converter Technologies
5	17PE23	Electromagnetic Interference and Compatibility
6	17PE24	Instrumentation in Electric Drives

Note: Students are required to choose two/one courses as Programme Elective- III & IV , depending on the add-on-courses opted in Semester I & II.

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M.Tech. (I Sem.) **17PE01 - COMPUTATIONAL MATHEMATICS**

L	T	P	Cr.
2	2	-	3

Pre-requisites: Control Systems, Elements of Signal Processing and Electrical Circuits-II

Course Educational Objective:
This course enables the student to make use of matrix theory, Fourier series, Z-transforms, FFT and wavelets in the field of power electronics and drives.

Course Outcomes: At the end of the course, student will be able to:
CO1: Analyze matrix theory
CO2: Solve differential equations using z-transform
CO3: Analyze Fourier, fast Fourier and wavelets and their applications in power electronics
CO4: Illustrate first and higher order derivatives

UNIT - I Advanced Matrix Theory
Matrix norms – QR decomposition for 3×3 matrices(Gram-schmidt process) — Eigen values - Generalized eigenvectors for 3×3 matrices and for upper triangular matrices of order 4×4 - Jordan canonical form for 3×3 matrices and for upper triangular matrices of order 4×4 – Singular value decomposition for 3×3 , 3×2, 2×3 matrices – Pseudo inverse for 3×3 matrices – Least square approximations for non homogeneous system of equations in 3 variables.

UNIT - II Z – Transforms
Transform of standard functions – Convolution – Initial and Final value problems – Shifting Theorem – Inverse transform (Using Partial Fraction – Residues) – Solution of difference Equations using Z – Transform.

UNIT - III Fourier Series
Euler"s formula - Dirichlet"s conditions – General Fourier series in the intervals $(0, 2\pi)$ and $(-\pi, \pi)$ –Fourier series expansion to different types of wave forms– change of intervals- Harmonic analysis .

UNIT - IV Fast Fourier Transform and wavelets
Discrete Fourier transform -Discrete convolution- Periodic sequence and circular convolution-Linear convolution through circular convolution – Fast Fourier transform – Decimation in time algorithm(up to 8 point DFT by Radix-2 FFT), decimation in frequency algorithm (up to 8 point DFT by Radix-2 FFT)- Computation of inverse DFT (up to 4 point DFT by Radix-2 FFT).
Wavelet theory, Definition of a wavelet-Scaling filter, Scaling function, Wavelet function, Wavelet transforms-Generalized transforms, Applications of wavelet transform.

UNIT - V Calculus of Variations
Variation and its properties – Euler"s equation – Functional dependent on first and higher order derivatives –Functional dependent on functions of several independent variables – Some applications – Direct methods: Ritz method and Galerkin method.

TEXT BOOKS

1. R. Bronson, "Matrix Methods", New Delhi, Elsevier, 2006.
2. B.S Grewal , "Higher engineering mathematics", Khanna publishers

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REFERENCES

1. S.S.Sastry , "Introductory numerical methods", PHI
2. A. Nagoor kani, "Digital signal processing", RBI publications
3. Elsgoltis, "Differential Equations and Calculus of Variations", Moscow, MIR Publishers, 1970
4. Erwin Kreyszig, "Advanced Engineering Mathematics", New Jersey, John Wiley & Sons, 2006.
5. T. Veerarajan," Engineering Mathematics", New Delhi, Tata McGraw-Hill, 2001.
6. Dr. Amit Konar, "Artificial Intelligence and Soft Computing- Behavioral and Cognitive Modeling of the Human Brain", New York, CRC Press LLC, 1999.
7. C. Sidney Burrus, Ramesh A. Gopinath, Haitao Guo, "Introduction to Wavelets and Wavelet Transforms: A Primer", 1st edition, Prentice hall,1998.

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M.Tech. (I Sem.) **17PE02 - ANALYSIS OF POWER CONVERTERS**

L	T	P	Cr.
2	2	-	3

Pre-requisites: Power Electronics

Course Educational Objective:
This course enables the student to illustrate advanced converter techniques and their control using various modulation techniques in modern power electronic systems.
Course Outcomes: At the end of the course, student will be able to:
CO1: Design control circuits for different power converters
CO2: Analyze different power electronic converters for engineering practices

UNIT- I: CONTROLLED RECTIFIERS
Review of 1-phase rectifiers, standards for harmonics in single-phase rectifiers, single-phase boost rectifier, voltage doubler PWM Rectifier, PWM rectifier in bridge connection, applications of unity power factor rectifiers, three-phase controlled Rectifiers-line-commutated controlled rectifiers, power factor, harmonic distortion, special configurations for harmonic reduction, harmonic standards and recommended practices, force-commutated three-phase controlled rectifiers-basic topologies and characteristics, numerical problems.

UNIT-II: DC CHOPPERS
Principle of operation, control strategies, step up and step down choppers, analysis of class A and class B choppers, chopper classification, analysis of one quadrant, two quadrant and four quadrant choppers, derivation of load voltage and current expressions, numerical problems.

UNIT-III: AC-AC CONVERTERS
Single phase AC voltage controllers with PWM control-effects of source and load inductances-synchronous tap changers-three Phase AC voltage controllers-analysis of Controllers with star and delta connected R and RL load-effects of source and load inductances-analysis of single phase and three-phase cyclo converters with R and RL loads, numerical problems.

UNIT-IV: DC-AC CONVERTERS
Voltage source and current source inverters- voltage control of single-phase inverters-sinusoidal PWM-modified PWM-phase displacement control-trapezoidal, staircase, stepped, harmonic injection and delta modulation-voltage control of three-phase inverters- sinusoidal PWM-third harmonic PWM-hysteresis current control PWM- space vector modulation-Comparison of PWM techniques-current source inverters-variable dc link inverter- numerical problems.

UNIT-V: MULTI LEVEL INVERTERS
Introduction, multilevel concept, types of multilevel inverters-diode clamped multilevel inverter, principle of operation, features of diode clamped inverter, improved diode clamped inverter-flying capacitors multilevel inverter, cascaded multilevel inverter.

TEXT BOOKS

1. Ned Mohan, Undeland and Robbin, "'Power Electronics: converters, Application and design", John Wiley and sons, Newyork, 2006.
2. Md.H.Rashid "Power Electronics", Pearson Education, 4th edition, 2014.

REFERENCES

1. Joseph Vithayathil, "Power Electronics: Principles and Applications", Delhi, Tata McGraw-Hill, 2017.
2. P.S. Bimbra, "Power Electronics", New Delhi, Khanna Publishers, 2012.

M.Tech. (I Sem.) **17PE03 - CONTROL OF MOTOR DRIVES - I**

L	T	P	Cr.
2	2	-	3

Pre-requisites: Power Electronics, Solid State Drives

Course Educational Objective:
This course enables the student to provide knowledge on steady state analysis & transient analysis of various motor drives and also design and analysis of different advanced power converters to control DC & AC motor drives.

Course Outcomes: At the end of the course, student will be able to:
CO1: Examine the steady state analysis of electric drives
CO2: Analyze current and speed controllers for solid state drives
CO3: Identify the factors that affect the speed control of induction motor drive
CO4: Analyze slip power recovery schemes

UNIT – I: CONVERTER CONTROLLED DC MOTOR DRIVES
Steady state analysis of the single and three phase fully controlled converter fed series and separately excited D.C motor drives: Continuous and discontinuous conduction mode, control of output voltage by sequence and sector control, harmonic analysis.

UNIT – II: CHOPPER CONTROLLED DC MOTOR DRIVES
Basic equations of motor operation-DC chopper Drives-Basic class A chopper circuit-Analytical properties of the load voltage waveforms-Analytical waveforms of the load current waveforms-Average current, r.m.s current and power transfer-Problems.

UNIT – III: STATOR SIDE CONTROL OF INDUCTION MOTOR
Scalar control- Voltage fed Inverter control-Open loop volts/Hz control-Speed control with slip regulation-Speed control with torque and Flux control-Current controlled voltage fed Inverter Drive. Current-Fed Inverter control-Independent current and frequency control-Speed and flux control in Current-Fed Inverter drive-Volts/Hz control of Current-Fed Inverter drive-Efficiency optimization control by flux program.

UNIT – IV: ROTOR SIDE CONTROL OF INDUCTION MOTOR
Rotor resistance control- fixed resistance control, variable resistance control-converter controlled resistance control, Slip power recovery schemes- Static Kramer drive-Phasor diagram-Torque expression-Speed control of Kramer drive-Static scherbius drive-Modes of operation.

UNIT – V: 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.

TEXT BOOKS

1. Shepherd, Hulley, Liang "Power Electronics and Motor Control", Cambridge University Press 2nd edition, 1996.
2. G. K. Dubey "Fundamentals of Electric Drives", Narosa Publications, 2nd edition, 2010.

REFERENCES

1. M.H.Rashid "Power Electronics Circuits, Devices and Applications", Pearson, 4th Edition, 2014.
2. R.Krishnan "Electric Motor Drives Modelling, Analysis and Control", Pearson, 1st edition, 2001.
3. S.B.Dewan, G.R.Slemon and A.Straughen, "Power Semiconductor Drives", Wiley Indian edition, 2013.

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M.Tech. (I Sem.)	17PE04 - OPTIMIZATION TECHNIQUES IN ELECTRICAL ENGINEERING	L	T	P	Cr.
		2	2	-	3

Pre-requisites: Engineering Mathematics

Course Educational Objective: This course enables the student to illustrate the fundamental concepts of Optimization Techniques of various classical and Evolutionary methods for constrained and unconstrained problems and their applications in electrical engineering.

Course Outcomes: At the end of the course, student will be able to :

CO1: Analyze linear and non-linear optimization problems in electrical engineering

CO2: Apply the concept of optimality criteria for various types of engineering problems

CO3: Apply the dynamic and meta-heuristic optimization techniques for engineering systems

UNIT-I: INTRODUCTION TO OPTIMIZATION

An overview of optimization problem, concepts and terms related to optimization, necessary and sufficient conditions for a multivariable function, Effects of scaling or adding a constant to an objective function, understanding of constrained and unconstrained optimization problems, properties of convex function and definiteness of a matrix and test for concavity of a function, numerical examples.

UNIT-II: LINEAR PROGRAMMING

Simplex method, matrix form of simplex method, solution of linear programming problems in tabular form via simplex method, Two-Phase simplex method, Duality in simplex method, Dual simplex method, Sensitivity analysis, pramater estimation of an induction motor using simplex method.

UNIT-III: NON-LINEAR PROGRAMMING

Lagrange multipliers, gradient descent method, steepest descent method, Gradient Based Methods: Newton-Raphson Method, Bisection Method, Secant Method, Davison-Fletcher-Powell method, Exterior point method, Direct Search Methods: Hooke-Jeeves pattern search method, Powell's Conjugate Direction Method, Interval Halving Method, Fibonacci Search Method, Non linear optimization technique to PWM signals using Lagrage Algorithm.

UNIT-IV: DYNAMIC OPTIMIZATION

Euler-Lagrange equation, optimal control with constraints on input, Dynamic programming-principle of optimality, concept of time optimal control problem and mathematical formulation of problem, solution of time-optimal control problem, numerical examples, Ripple control in power electronic system using dynamic programming optimization.

UNIT-V: META HEURISTIC OPTIMIZATION TECHNIQUES

Genetic Algorithms, Particle Swarm Optimization, Covariance Matrix Adoption Evaluation Strategies, Optimal timing of over current relay control using PSO algorithm..

TEXT BOOKS

1. S. Rao ,"Engineering Optimization – Theory and Practice", 3rd edition, John Wiley & Sons., 2009.
2. Kalyanmoy Deb, "Optimization for Engineering Design - Algorithms and Examples", PHI Learning Private Ltd, New Delhi, 2nd edition,2012.

REFERENCES

1. K.V. Mittal and C Mohan, "Optimization Methods in Operations Research and Systems Analysis", 2nd edition 1983, New Age International Publishers, New Delhi.
2. Christos H Papadimitriou and Kenneth Steiglitz, "Combinatorial Optimization – Algorithms and Complexity", Prentice Hall of India 1997.
3. J C Pant, "Introduction to Optimization & Operations Research", 4th eEdition, Jain Brothers, New Delhi.
4. D.E. Goldberg, "Genetic Algorithms in Search, optimization and machine learning: Reading, Mass", Addison-Wesley, 1989.
5. Winston, WL and Venkataramanan, M,"Introduction to Mathematical Programming", 4th Edn., Duxbury Press, 2002.
6. Pei Yunqing, Toshifumi ISE, and Wang Zhaoan, "A Simulation Algorithm and Parameter Optimization of Power Electronic System including Motor Drives", IEEE conference, 1998.
7. Vinicius Novicki Obadowski, Andre Arthur Perleberg, Wagner de Freitas, " A non linear optimization technique applied to PWM signals", IEEE conference, 7-9 November, 2012.
8. D. L. Logue and P. T. Kre, "Optimization of Power Electronic Systems Using Ripple Correlation Control: A Dynamic Programming Approach", IEEE conference, 2001.
9. Anand K Pandey and Sheeraz Kirmani, "Implementation of Gentetic Algorithm to find the optimal timing of Overcurrent relays", IEEE conference, 2016.

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M.Tech. (I Sem.)	17PE05 - HVDC AND FACTS	L	T	P	Cr.
		2	2	-	3

Pre-requisites: Electrical Power Transmission, Power Electronics

COURSE EDUCATIONAL OJECTIVES:
This course enables the student to illustrate HVDC & FACTS technologies, their evolution and analysis.

COURSE OUTCOMES: At the end of the course, student will be able to:
CO1. Outline the HVDC technology and conversion principles used in power transmission
CO2. Analyze converters used in HVDC transmission system
CO3. Design FACTS controllers for power flow and stability applications

UNIT - I: HVDC TRANSMISSION SYSTEMS
Types of dc links, schematic of HVDC transmission system, greatz circuit, converter control characteristics, principle of D.C link control, starting and stopping of D.C link, Multi terminal DC links-Types-Series, Parallel and series-parallel systems, modern trends in HVDC Transmission systems.

UNIT - II: HVDC SYSTEM CONTROL, FAULTS, HARMONICS &FILTERS
Basic controllers - constant ignition angle, constant current and constant extinction/ advance angle control, power control, high level controllers. Converter mal operations - misfire, arc through, commutation failure. Converter fault types-D.C fault, A.C fault– protection against over-current and over-voltage in converter station, types of harmonics in HVDC systems, types of filters-AC and DC filters.

UNIT - III: FACTS CONCEPTS
Power flow in AC systems-Definitions of FACTS-Basic types of FACTS controllers-power flow control- constraints of maximum transmission line loading-loading capability limits-dynamic stability considerations-benefits from FACTS controllers.

UNIT - IV: SERIES & SHUNT COMPENSATIONS
Concepts of static series compensation using GCSC, TCSC and TSSC, applications, Static Synchronous Series Compensator (SSSC)-Principles of shunt compensation–Variable Impedance type & switching converter type- Static Synchronous Compensator (STATCOM) configuration, characteristics and control.

UNIT - V: UPFC & IPFC
Introduction: The Unified Power Flow Controller-Basic Operating Principles, Conventional Transmission Control Capabilities, Independent Real and Reactive Power Flow Control, Control Structure, Basic Control system for P and Q Control, basic principle, schematic representation of Interline Power Flow Controller, characteristics and control.

TEXT BOOKS
1. E.W. Kimbark "Direct current Transmission", Wiley Inter Science, New York.
2. N.G.Hingorani and L.Guygi "Understanding FACTS Devices", IEEE Press, 2001.

REFERENCES
1. J Arrillaga, "High Voltage Direct current Transmission", Peter Peregrinus Ltd, UK
2. Padiyar K. R., "FACTS Controller in Power Transmission and Distribution", New Age International Private Limited, 2008.
3. K.R.Padiyar "HVDC Power Transmission Systems," Wiley Eastern Ltd.2nd edition, 2010.

M.Tech. (I Sem.) **17PE06 - ENERGY AUDITING AND MANAGEMENT**

L	T	P	Cr.
2	2	-	3

Pre-requisites: Electrical Machines, Transmission and Distribution of Electrical Energy, Utilization of Electrical Energy.

Course Educational Objective:

This course enables the student to emphasize the significance of energy audit and management of various electrical equipment.

Course Outcomes:

At the end of the course, students will be able to:

CO1. Illustrate the concepts of energy auditing and management

CO2. Employ energy management strategies for electric machines and lighting systems

CO3. Develop suitable energy management strategies for metering and instrumentation

CO4. Analyze the economics of different energy management strategies

UNIT-I: BASIC PRINCIPLES OF ENERGY AUDIT

Basics of Energy – Need for energy management – Energy accounting - Energy monitoring, targeting and reporting - Energy audit process.

UNIT-II: ENERGY AUDIT OF ELECTRIC MACHINES

Energy conservation in motors-appropriate loading of motors-direct electrical measurements-slip measurement-amperage readings- selection of right motors- assessing motor and drive system operating conditions-motor rewinding– Transformer and reactors - Capacitors and synchronous machines.

UNIT-III: LIGHTING SYSTEMS & COGENERATION

Indroduction-energy efficient lighting systems-high efficiency fluorescent lamps-compact fluorescent lamps-LED lamps-compact halogen lamps-electronic ballasts-Energy management in lighting systems – Task and the working space - Lighting controls – Optimizing lighting energy – Power factor and effect of harmonics, lighting and energy standards, energy management by cogeneration – Forms of cogeneration – Feasibility of cogeneration – Electrical interconnection

UNIT-IV: METERING FOR ENERGY MANAGEMENT

Units of measure - Utility meters – Demand meters – Paralleling of current transformers – Instrument transformer burdens – Multi tasking solid state meters, metering location vs. requirements, metering techniques and practical examples.

UNIT-V: ECONOMIC ASPECTS AND ANALYSIS

Economic analysis – Economic models - Time value of money - Utility rate structures – Cost of electricity – Loss evaluation, load management – Demand control techniques – Utility monitoring and control system – HVAC and energy management – Economic justification.

TEXT BOOKS

1. Amit K. Tyagi, 'Handbook on Energy Audits and Management', The Energy and Resources Institute, 2003
2. John .C. Andreas,"Energy efficient electric motors " Marcel Dekker Inc Ltd, 2nd edition, 1995

REFERENCES

1. W.R. Murphy & G. Mckay Butter worth "Energy management", Elsevier publications. 2012
2. Barney L. Capehart, Wayne C. Turner, and William J.Kennedy, "Guide to Energy Management", 5th Edition, The Fairmont Press, Inc., 2006.
3. Sonal Desai, "Hand book of energy audit", MCH publisher, 2015
4. Amlan Chakrabarti, " Energy engineering and management", PHI publisher, 2011.
5. Moncef Kranti, "Energy audit of building systems: An engineering approach", 2nd edition, CRC press, 2011.
6. IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities, IEEE, 1996.

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L	T	P	Cr.
2	2	-	3

M.Tech. (I Sem.) **17PE07 - MACHINE MODELING AND ANALYSIS**

Prerequisites: Electrical Machines

Course Objective: This course enables the student to gain knowledge on modeling and analysis of all rotating machines under dynamic and steady state conditions.

Course Outcomes: At the end of the course, student will be able to:

CO1: Develop models for linear and nonlinear magnetic circuits

CO2: Develop torque equation of an electrical machine using the concepts of field Energy

CO3: Construct machine models based on different reference frames

CO4: Synthesize equivalent circuit parameters for synchronous and asynchronous machines

UNIT – I: BASIC CONCEPTS OF MODELING

Basic Two-pole Machine representation of Commutator machines, 3-phase synchronous machine with and without damper bars and 3-phase induction machine, Kron's primitive Machine-voltage, current and Torque equations.

UNIT – II: DC MACHINE MODELING

Mathematical model of separately excited D.C motor – Steady State analysis-Transient State analysis-Sudden application of Inertia Load-Transfer function of Separately excited D.C Motor-Mathematical model of D.C Series motor, Shunt motor-Linearization Techniques for small perturbations.

UNIT – III: MODELING OF 1-PHASE INDUCTION MOTOR

Linear transformation-Phase transformation - three phase to two phase transformation (abc to $\alpha\beta0$) and two phase to three phase transformation ($\alpha\beta0$ to abc) --Power equivalence.-Modelling of 1-Phase induction motor-cross field theory-mathematical modelling of 1-phase induction motor.

UNIT – IV: MODELING OF THREE PHASE INDUCTION MACHINE

Generalized model in arbitrary reference frame-Electromagnetic torque-Derivation of commonly used Induction machine models- Stator reference frame model-Rotor reference frame model-Synchronously rotating reference frame model-state space model with flux linkages as variables, small signal equations of induction motor-derivations-DQ flux linkage model derivation-control principles of induction motor.

UNIT – V: MODELLNG OF SYNCHRONOUS & SPECIAL MACHINES

Synchronous machine inductances – Mathematical model-transformation to the rotor's dq0 reference frame- Flux linkages in terms of winding currents-referring rotor quantities to the stator- voltage equations in the rotor's dq0 reference frame-electromagnetic torque-currents in terms of flux linkages-steady state operation- modelling of PM Synchronous motor, modelling of BLDC motor, modelling of Switched Reluctance motor.

TEXT BOOKS

1. R.Krishnan "Electric Motor Drives - Modelling, Analysis& control", Pearson Publications, 1st edition -2002
2. P.C.Krause, Oleg Wasynczuk, Scott D.Sudhoff "Analysis of Electrical Machinery and Drive systems", Second Edition, June 2013, IEEE Press

REFERENCES

1. P.S.Bimbra "Generaized Theory of Electrical Machines ", Khanna publications, 2014.
2. Chee Mun Ong "Dynamic simulation of Electric machinery using Matlab / Simulink", Prentice Hall, 1997.

M.Tech. (I Sem)	17PE08 - ANALYSIS OF SPECIAL ELECTRICAL MACHINES	L	T	P	Cr.
		2	2	-	3

Pre-requisites: Electrical machines, Control systems

Course Educational Objectives: This course enables the students to analyze the characteristics and different control schemes used in special electrical machines.

Course Outcomes : At the end of the course, student will be able to :

CO1 : Analyze the characteristics of different types of special machines

CO2 : Differentiate working principles of special machines

CO3 : Classify single phase motors

UNIT- I: STEPPING MOTORS

Constructional features - principle of operation - modes of excitation - torque production in Variable Reluctance (VR) stepping motor – Characteristics - Linear and Non Linear Analysis - Drive systems and Control of stepping motor.

UNIT- II : SYNCHRONOUS RELUCTANCE MOTORS

Constructional features of axial and radial air gap Motors - operating principle - reluctance torque – phasor diagram - motor characteristics.

PERMANENT MAGNET SYNCHROUNOUS MOTORS

Principle of operation – EMF and Torque equations - Phasor diagram - Power controllers – Torque speed characteristics – Self control, Vector control, Microprocessor based control schemes.

UNIT- III: SWITCHED RELUTCANCE MOTORS

Constructional features-principle of operation-Inductance profile-Torque equation- Types of Power controllers and converter topologies used – Current control schemes – Torque Speed Characteristics – Hysteresis and PWM -Microprocessor based controller and Sensorless Controller.

UNIT- IV : PERMANENT MAGNET BRUSHLESS DC MOTORS

Commutation in DC motors, Difference between mechanical and electronic commutators, Hall sensors, Optical sensors, Multiphase Brushless motor, Square wave permanent magnet brushless motor drives, Torque and Emf equation, Torque-Speed characteristics, Controllers-Magnetic Circuit Analysis-Microprocessor based controller.

UNIT- V: LINEAR MOTORS

Linear Induction Motor (LIM) classification – construction – Principle of operation – Concept of current sheet – goodness factor – DC Linear Motor (DCLM) types – circuit equation - DCLM control applications – Linear Synchronous Motor(LSM) – Types - Performance equations – Applications.

TEXT BOOKS

1. Miller, T.J.E. “Brushless Permanent Magnet and Reluctance Motor Drives”, Clarendon Press, Oxford, 1989.
2. Kenjo, T, “Stepping Motors and their Microprocessor control”, Clarendon Press,Oxford, 1989.

REFERENCES
1. EG Janardanan, "Special Electrical machines" PHI, 2014.
2. J Gnanavadivel, "Special Electrical Machines " AnuRadha Publications
3. Kenjo, T and Naganori, S "Permanent Magnet and brushless DC motors", Clarendon Press, Oxford, 1989.
4. P.S.Bimbra, " Generalized Theory of Electrical Machines ", Khanna publications, 5th edition, 1995.
5. R.Krishnan, "Switched Reluctance Motor Drives – Modeling, Simulation, Analysis, Design and Application", CRC Press, New York, 2001.

LBRCE EXAM CELL

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M.Tech. (I Sem.)	17PE09 - MODELING AND SIMULATION OF POWER ELECTRONIC SYSTEMS	L	T	P	Cr.
		2	2	-	3

Prerequisites: Power Electronics Lab, Analysis of Power Converters

Course Educational Objective: This course enables the student to model and simulate various power electronic converters using software tools.

Course Outcome:

At the end of the course, student will be able to:

CO1. Develop mathematical models for different power electronic converters

CO2. Simulate various power converters using PSPICE and MATLAB

CO3. Analyze power electronic circuits for different loads

UNIT - I: INTRODUCTION

Need for Simulation - Challenges in simulation - Classification of simulation programs - Overview of PSPICE, MATLAB and SIMULINK.

Review of numerical methods. Application of numerical methods to solve transients in D.C. Switched R, L, R-L, R-C and R-L-C circuits- Extension to AC circuits.

UNIT – II: MODELING & SIMULATION OF POWER SEMICONDUCTOR DEVICES

Modelling and simulation of diode, SCR, TRIAC, IGBT and Power Transistors -Application of numerical methods to power electronic switches- Simulation of gate/base drive circuits and snubber circuits (using MATLAB and PSPICE).

UNIT – III: MODELING & SIMULATION OF RECTIFIERS

Mathematical modelling and simulation of single phase and three phase semi, fully controlled rectifiers with R, R-L and R-L-E loads using MATLAB/SIMULINK.

UNIT – IV: MODELING & SIMULATION OF CHOPPERS

Mathematical modelling and simulation of buck, boost and buck-boost converters with R, R-L and R-L-E loads using MATLAB/SIMULINK.

UNIT – V: MODELING & SIMULATION OF INVERTERS

Mathematical modelling and simulation of single phase and three phase half and full bridge inverter with R and R-L loads using MATLAB/SIMULINK.

TEXT BOOKS

1. Robert Ericson, "Fundamentals of Power Electronics", Springer Publication, 2001.
2. Issa Batarseh, "Power Electronic Circuits", John Wiley, July 2006, Simulink Reference Manual, Math works, USA

REFERENCES

1. Simulink Reference Manual, Math works, USA.
2. Joseph Vithayathil, "Power Electronics: Principles and Applications", Delhi, Tata McGraw-Hill, 2010.
3. P.S. Bimbra, "Power Electronics", New Delhi, Khanna Publishers, 2012.
4. M.H.Rashid,"SPICE for circuits and Electronics using PSPICE",Prentice Hall,2011

M.Tech. (I Sem.) 17PE60 - POWER CONVERTERS AND DRIVES-I LAB

L	T	P	Cr.
-	-	2	1

Pre-requisites: Power Electronics, Solid State Drives

Course Educational Objective: This course enables the student to get hands on experience on various power semiconductor devices, converter circuits and drives through experimentation.

Course Outcomes: At the end of the course, student will be able to:

CO1: Control DC and AC drives using hardware controllers

CO2: Examine the characteristics of power electronic devices

CO3: Analyze the performance of different power electronic converters and drives using various hardware modules

LIST OF EXPERIMENTS

Hardware based:

1. Switching characteristics of power diode, BJT, MOSFET, IGBT and SCR using bread board
2. Determination of output voltage and characteristics of 1-phase dual converter with RL load
3. Determination of output voltage and frequency of 1-phase step down cyclo converter with R & RL loads for different firing angles
4. Output voltage characteristics of 3-phase IGBT based PWM Inverter on R & R-L loads for different modulation indices
5. Output voltage characteristics of diode clamped multi- level inverter with R & RL loads
6. Speed control of three phase converter controlled dc motor drive
7. Study and analyze the performance of four quadrant operation of chopper fed dc motor drive at different firing angles
8. Determination of speed and output voltage of 3-phase A.C. Voltage controller fed induction motor drive
9. Starting and Running characteristics of capacitor start & capacitor run single phase Induction Motor
10. Output voltage characteristics of flying capacitors multi- level inverter- fed induction motor drive

Additional Experiments

11. Speed control of a three- phase slip ring Induction motor by Static Rotor Resistance Control
12. Speed control of a three- phase induction motor drive using vector control method

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M.Tech. (I Sem.)

17PE61 - SIMULATION OF POWER CONVERTERS AND DRIVES-I LAB

L	T	P	Cr.
-	-	2	1

Pre-requisites: Power Electronics, Solid State Drives

Course Educational Objective: This course enables the student to get hands on experience on various power semiconductor devices, converter circuits and drives using simulation tools.

Course Outcomes: At the end of the course, student will be able to:

CO1: Design various power electronic converters using software

CO2: Simulate various power electronic devices to analyze their performance

CO3: Design and control AC & DC drives using software tools

LIST OF EXPERIMENTS

Simulation based:

1. Switching characteristics of power diode, BJT, MOSFET, IGBT and SCR
2. Output voltage and current characteristics of 1-phase step down cyclo converter with R & RL loads for different firing angles
3. Output voltage and current characteristics of 3-phase IGBT based PWM Inverter on R & R-L loads
4. Output voltage and current characteristics of diode clamped multi level inverter with R & RL loads using PWM technique
5. Speed control of three phase converter controlled dc motor drive using PWM technique
6. Starting and Running characteristics of capacitor start & capacitor run single phase induction motor using PWM control technique
7. Torque and speed characteristics of four quadrant chopper fed dc motor drive
8. Determination of speed and output voltage of 3-phase A.C. Voltage controller fed induction motor drive using PWM technique
9. Speed control of 3 phase Induction motor with SPWM technique
10. Output voltage and current characteristics of flying capacitors multi level inverter fed to induction motor drive using PWM technique

Additional Experiments

11. Torque and speed control of 3 phase slip ring Induction motor by Static Rotor Resistance Control using control switches
12. Torque and speed control of three phase induction motor drive using vector control technique

LBRCE EXAM CELL

M. Chandra

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M.Tech.(I Sem)	17PE90 - ADVANCED POWER SEMICONDUCTOR DEVICES AND THEIR PROTECTION	L	T	P	Cr.
		3	-	-	3

Pre-requisites : Basic Electronic Circuits & Devices, Power Electronics

Course Educational Objective: This course enables the student to understand switching characteristics, design of gate drive and protection circuits for various power semiconductor devices.

Course Outcomes: At the end of the course, student will be able to:

CO1: Analyze switching characteristics of different power semiconductor devices

CO2: Design various protection circuits

CO3: Develop gate driver circuits for power semiconductor devices

CO4: Design passive components and noise sources

UNIT- I: BJTS & MOSFETS

BJTs : Introduction- vertical power transistor structures-I-V characteristics-physics of BJT operation switching characteristics-break down voltages-second break down-on-state losses-safe operation areas design of drive circuits for BJTs-snubber circuits for BJTs and darlingtons

MOSFETs : Introduction-basic structures-I-V characteristics-physics of device operation-switching characteristics-operation limitations and safe operating areas-design of gate drive circuits, snubber circuits.

UNIT -II: IGBTs & IGCTs

IGBTs : Introduction-basic structures-I-V characteristics-physics of device operation-Latch in IGBTs switching characteristics-Device limits and safe operating areas-drive and snubber circuits.

IGCTs: Introduction-basic structures-I-V characteristics-physics of device operation-Integrated Gate Commutated Thyristors (IGCTs) switching characteristics-Device limits and safe operating areas-drive and snubber circuits.

UNIT -III: EMERGING DEVICES AND CIRCUITS

Introduction-basic structures- I-V characteristics-physics of device operation-GTO switching characteristics-snubber circuits-over protection of GTOs-Power junction field effect transistors-field controlled Thyristor-JFET based devices versus other power devices-MOS controlled Thyristors-high voltage integrated circuits-new semiconductor materials

UNIT -IV: PASSIVE COMPONENTS, ELECTROMAGNETIC COMPATIBILITY AND NOISE

Introduction-design of inductor-transformer design-selection of capacitors-resistors current measurements-heat sinking circuit lay out –Electromagnetic Interference (EMI)-Sources of EMI-Electromagnetic Interference in Power Electronic Equipment. Noise sources in SMPS-Diode Storage Charge Noise-Noise generated due to switching-Common noises sources in SMPS-Noise due to high frequency transformer- conducted noise measurement - minimizing EMI-EMI shielding-EMI standards.

UNIT-V: PROTECTION OF DEVICES & CIRCUITS

Cooling & Heat sinks – Thermal modeling of power switching devices- snubber circuits – Reverse recovery transients – Supply and load side transients – voltage protections – current protections- commercially available power semiconductor devices and their ratings.

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TEXT BOOK:

1. Ned Mohan, Undeland and Robbin, "Power Electronics: converters, Application and design", John Wiley and sons, Newyork, 2006.
2. W.C.Lander, "Power Electronics Circuits", Mcgraw Hill companies, 3rd edition, 1993.

REFERENCES

1. Md.H.Rashid "Power Electronics", Pearson Education, 4th edition, 2014.
2. Vithayathil, " Power Electronics Circuits", Mcgraw Hill Education, 1st edition, 2010

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L	T	P	Cr.
2	2	-	3

M.Tech. (II Sem.) **17PE10 - MODERN CONTROL THEORY**

Prerequisite: Linear control system

Course Educational Objective: This course enables the student to learn modern state-space methods to design and analyze continuous-time control systems.

Course outcomes: At the end of the course, student will be able to:

CO1: Analyze the state-space model of continuous linear and non-linear systems

CO2: Apply Lyapunov stability theorem to non-linear LTI systems

CO3: Identify expected state-space trajectories

CO4: Formulate the optimal control problems

UNIT – I: MODEL CONTROL

Introduction to controllability and observability- Effect of state feedback on controllability and observability, Design of State Feedback Control through Pole placement, Full order observer and reduced order observer.

UNIT – II: DESCRIBING FUNCTION ANALYSIS

Introduction to Non Linear Systems, behaviour of nonlinear systems, properties of Nonlinear Systems, Types of Nonlinearities – Saturation – Dead Zone – Hysteresis-Relay-Backlash etc, Introduction to Linearization of nonlinear systems, Describing function (DF)– Derivation of general DF, DF for different nonlinearities -saturation, Dead-Zone-Dead-Zone and Saturation, Hysteresis-Backlash .Stability analysis of Non – Linear systems through describing functions.

UNIT – III: PHASE PLANE ANALYSIS

Introduction to phase plane analysis, singular points, and their classification, limit cycle and behaviour of limit cycle- Analytical method, Isoclines method, and delta method for constructing Trajectories, phase plane analysis of nonlinear control systems.

UNIT – IV: STABILITY ANALYSIS

Stability of equilibrium state, asymptotic stability, graphical representation, Lyapunov stability theorems, stability analysis of linear and nonlinear systems, construction of Lyapunov functions using– Krasovskii and variable gradient methods.

UNIT –V: OPTIMAL CONTROL

Introduction, Formulation of optimal control problems- Minimum time, Minimum energy, minimum fuel problems- State regulator problem- Output regulator problem-Tracking problem, calculus of variations – fundamental concepts, minimization of functional, Linear quadratic regulator, Linear Quadratic Gaussian(LQG).

TEXT BOOKS

1. I.J. Nagrath and M. Gopal, "Control Systems Engineering", New Age International Publishers,Sixth edition ,2017
2. Ashish Tewari, "Modern control Design with Matlab and Simulink", John Wiley, New Delhi,2005.

REFERENCES

1. Jinzhi Wang, Zhisheng Duan, Ying Yang, Lin Huang, "Analysis and Control of Nonlinear Systems with Stationary sets-Time domain and Frequency domain methods", World Science publishing co.Pvt Ltd, 2009.
2. George J. Thaler, 'Automatic Control Systems', Jaico Publishers, 1993.
3. M.Gopal'Modern control system theory', New Age International Publishers, 2014.
4. Gene F. Franklin, J. David Powell and Abbasemami-Naeini, "Feedback Control of Dynamic Systems", seventh edition, Pearson Education,2015

M.Tech. (II Sem.)	**17PE11 - SWITCHED MODE POWER CONVERSION**	L	T	P	Cr.
		2	2	-	3

Pre-requisites: Analysis of Power Converters

Course Educational Objective: This course enables the student to understand principles and basic topologies of switched mode power converters.

Course Outcomes: At the end of the course, student will be able to:

CO1: Identify various types of switched mode converter topologies

CO2: Design DC-DC converters of different topologies

CO3: Analyze soft switching techniques

CO4: Analyze different types of power factor correction circuits

UNIT-I: NON ISOLATED SWICHMODE POWER CONVERSION

Analysis & Designing of Buck converters, Boost converters, Buck-Boost converters, Cuk converters-continuous and discontinuous modes, applications, problems.

UNIT-II: ISOLATED SWICHMODE POWER CONVERSION

Requirement for isolation in the switch-mode converters, transformer connection, Forward and fly back converters, power circuit and steady state analysis-Applications. Push Pull Converters: Power circuit and steady state analysis-utilization of magnetic circuits in single switch and push-pull topologies- Applications, Half bridge and full bridge converters- Power circuit and steady state analysis-Utilization of magnetic circuits and comparison with previous topologies-Applications.

UNIT -III: SOFT SWITCHING CONVERTERS

Classification of Resonant converters-Basic resonant circuits- Series resonant circuit-Parallel resonant circuits- Resonant switches, Concept of Zero voltage switching-Principle of operation, analysis of M-type and L-type Buck or boost Converters-Concept of Zero current switching-Principle of operation-Analysis of M-type and L-type Buck or boost Converters.

UNIT- IV: POWER FACTOR CORRECTION CIRCUITS

Introduction, Definition of PF and THD, Power Factor Correction , Energy Balance in PFC Circuits , Passive Power Factor Corrector, Basic Circuit Topologies of Active Power Factor Correctors , System Configurations of PFC Power Supply, CCM Shaping Technique , Current Mode Control, Voltage Mode Control, Other PFC Techniques.

UNIT- V: CONTROL METHODS FOR SWITCHING POWER CONVERTERS

Control methods for buck, boost and forward dc-dc converters using State-space Modelling, Converter Transfer Functions, Pulse Width Modulator Transfer Functions, and Linear Feedback Design Ensuring Stability.

TEXT BOOKS

1. Ned Mohan, Undeland and Robbin, 'Power Electronics: converters, Application and design', John Wiley and sons, Newyork, 2007.
2. Robert Erickson and Dragon Maksivimovic "Fundamentals of Power Electronics", Springer Publications, 2nd edition, 2001.

REFERENCES

1. Philip T.Krein "Elements of Power Electronics", Oxford University Press, 2nd edition, 2014.
2. L. Umanand "Power Electronics Essentials & Applications", Wiley India Private Limited, 2011.
3. Issa Batarseh "Power Electronics Circuits", John Wiely, 2006.
4. Md.H.Rashid "Power Electronics", Pearson Education, 4th edition, 2014.

M.Tech. (II Sem.)	17PE12 - CONTROL OF MOTOR DRIVES - II	L	T	P	Cr.
		2	2	-	3

Pre-requisites: Power Electronics, Solid State Drives

Course Educational Objective: This course enables the student to illustrate the operation of electric drives controlled from a power electronic converter and to introduce the design concepts of controllers. It also deals with the steady state operation and transient dynamics of a motor-load system.

Course Outcomes: At the end of the course, student will be able to:

CO1: Analyze DTC & sensor less vector controls of induction motor

CO2: Control AC drives with different controlling strategies

CO3: Identify different types of AC motor drives based on application

UNIT – I: DTC & SENSORLESS VECTOR CONTROL OF INDUCTION MOTOR

Direct torque control of induction motor drives, Sensorless vector control-slip and speed Estimation at low performance, Rotor Angle and Flux linkage Estimation at high performance -rotor Speed Estimation Scheme- estimators using rotor slot harmonics, Model Reference adaptive systems, Extended Kaman Filter, injection of auxiliary signal on salient rotor.

UNIT – II :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.

UNIT – III :CONTROL OF SWITCHED RELUCTANCE MOTOR DRIVES

SRM-principle of operation, Design aspects of stator and rotor pole arcs, torque equation, torque-speed characteristics-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.

UNIT-IV :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.

UNIT-V :CONTROL OF LINEAR MOTORS

Types of linear motors, construction details-Flat LIMs, Tubular LIMs, LIM equivalent circuit, Design considerations, applications of LIM, Control of Linear induction motor- Linear synchronous motor (LSM), Principle of operation, Types of LSM, Iron core LSM and Air core LSM, Control of LSM.

TEXT BOOKS

1. MD Murphy & FG Turn Bull "Power Electronics control of AC motors", Franklin Book Co, 1st edition, 1998.
2. B. K. Bose "Modern Power Electronics and AC Drives", Prentice Hall, 1st edition, 2001.

REFERENCES

1. R. Krishnan "Electric Motor Drives Modelling, Analysis and Control", Pearson, 1^{st} edition, 2001.
2. G. K. Dubey "Fundamentals of Electric Drives", Narosa Publications, 2^{nd} edition, 2010.
3. Peter Vas "Sensor less Vector Direct Torque control", Oxford University Press, 1998.
4. Venkataratnam "Special electrical Machines", University press, 1^{st} edition, 2008.
5. S.B.Dewan, G.R.Slemon and A.Straughen, "Power Semiconductor Drives", Wiley Indian edition, 2013.

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M.Tech. (II Sem.)	17PE13 - POWER QUALITY ENGINEERING	L	T	P	Cr.
		2	2	-	3

Pre-requisites: Electrical Power Transmission, Power Electronics

Course Educational Objective: This course enables the student to identify the power quality issues and suitable power conditioners for improvement of power quality.

Course Outcomes: At the end of the course, student will be able to:
CO1: Differentiate between different types of power quality problems
CO2: Identify the sources of power quality problems
CO3: Analyze the power quality monitoring equipment and power quality standards
CO4: Apply power quality mitigation methods to improve power quality
CO5: Interpret the power quality benchmarking process

UNIT - I: OVERVIEW OF POWER QUALITY
Power quality (PQ) problem, Voltage sag, Swell , Surges, Harmonics, over voltages, spikes, Voltage fluctuations, Transients, interruption overview of power quality phenomenon , Remedies to improve power quality, power quality monitoring.

UNIT - II: VOLTAGE SAGS AND INTERRUPTIONS
Sources of sags and interruptions-Estimating Voltage sag performance-Fundamental principles of protection-Solutions at the End-User level-Evaluating the economics of different ride_ through alternatives-Motor_ starting sags-Utility system fault_ clearing issues.

UNIT - III: HARMONICS
Harmonic Distortion-Voltage versus current distortion-Harmonic versus Transients-Power system Quantities under non sinusoidal conditions-Harmonic indices-Harmonic sources from commercial loads-Harmonic sources from industrial loads-Locating harmonic sources- System response characteristics-Effects of harmonic distortion- Inter harmonics-Harmonic Distortion Evaluation-Principles of Controlling Harmonics- Harmonic studies-Devices for controlling Harmonics- Harmonic filter Design.

UNIT - IV: POWER QUALITY MONITORING & MITIGATION
Monitoring considerations-Historical perspective of power quality measuring instruments-Power quality measurement equipment-Assessment of power quality measurement data-Application of intelligent systems-Power quality monitoring standards.
Overview of mitigation methods – from fault to trip, reducing the number of faults, reducing the fault clearing time, changing the power system, installing mitigation equipment, improving equipment immunity, different events and mitigation methods.

UNIT - V: POWER QUALITY BENCHMARKING
Introduction, Benchmarking process, power quality contracts, power quality insurance, power quality state estimation, power quality in distribution planning.
Wiring and Grounding: Definitions and resources, reasons for grounding, typical wiring and grounding problems, solutions to wiring and grounding problems.

TEXT BOOKS

1. M.H.J Bollen, "Understanding Power Quality Problems: Voltage Sags and Interruptions", New York: IEEE Press, 2000.
2. Roger. C. Dugan, Mark. F. McGranagham, Surya Santoso, H.Wayne Beaty, "Electrical Power Systems Quality" McGraw Hill,3rd edition,2012.

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REFERENCES

1. G.T. Heydt, "Electric Power Quality", 2nd Edition, West Lafayette Stars Circle Publications, 1994.
2. J. Arrillaga, N.R. Watson, S. Chen, "Power System Quality Assessment", New York: Wiley, 2003.
3. C. Sankaran, "Power Quality", CRC Press, Second Indian reprint 2011.
4. Math H.J.Bollen, "Understanding Power Qulaity Problem", Wiley, IEEE press, 2016.

M. Chnallen

M.Tech. (II Sem.) **17PE14 - HYBRID ELECTRICAL VEHICLES**

L	T	P	Cr.
2	2	-	3

Pre-requisites: Control system, Power Electronics, Solid State Drives

Course Educational Objective: This course enables the student to illustrate the characteristics, architecture, control and management strategies of hybrid electric vehicles.

Course Outcomes: At the end of the course, student will be able to:
CO1 : Explore fundamental concepts of hybrid electric vehicles
CO2 : Analyze the performance of electric and hybrid electric vehicles
CO3 : Illustrate different energy management strategies for hybrid electric vehicles

UNIT – I: INTRODUCTION
History of hybrid electric vehicles, social and environmental importance of hybrid electric vehicles, impact of modern drive-trains on energy supplies. Conventional Vehicles- Basics of vehicle performance, vehicle power source characterization, transmission characteristics and mathematical models to describe vehicle performance.

UNIT – II: HYBRID ELECTRIC DRIVE-TRAINS
Electric Drive-trains: Basic concepts of electric traction, introduction to various electric drives-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis. Basic concepts of hybrid traction- introduction to various hybrid drives-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.

UNIT – III: ELECTRIC PROPULSION
Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Induction Motor drives, Permanent Magnet Motor drives, Switched Reluctance Motor drives, drive system efficiency.

UNIT – IV: DRIVE SYSTEM
Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor and power electronics, selecting the energy storage technology, Communications, supporting subsystems.

UNIT – V: ENERGY MANAGEMENT STRATEGIES
Introduction, classification and comparison of different energy management strategies, implementation issues of energy management strategies.
Case Studies: Design of Hybrid Electric Vehicle (HEV), Battery Electric Vehicle (BEV).

TEXT BOOKS

1. Iqbal Hussein, "Electric and Hybrid Vehicles: Design Fundamentals", CRC Press, 2003.
2. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design", CRC Press, 2004.

REFERENCES

1. James Larminie, John Lowry, "Electric Vehicle Technology Explained",Wiley, 2003.
2. Chris MI, M. Abul and David Wenzhong Gao , "Hybrid Electrical Vehicle Principles and Application with Practical Perspectives".

M.Tech. (II Sem.) **17PE15 - REACTIVE POWER MANAGEMENT**

L	T	P	Cr.
2	2	-	3

Pre-requisites : Power Electronics, Power Quality, Power Systems

Course Educational Objective: This course enables the student to identify the necessity of reactive power compensation in real time applications and characterize distribution side and utility side reactive power management strategies.

Course Outcomes: At the end of the course, student will be able to:

CO1 : Illustrate the significance of load compensation in symmetrical and unsymmetrical loads
CO2 : Analyze different types of reactive power compensation in transmission systems
CO3 : Develop models for reactive power coordination
CO4 : Interpret the economic aspects of reactive power management

UNIT - I: LOAD COMPENSATION

Objectives and specifications – reactive power characteristics – inductive and capacitive approximate biasing – Load compensator as a voltage regulator – phase balancing and power factor correction of unsymmetrical loads- examples.

UNIT - II: STEADY STATE REACTIVE POWER COMPENSATION IN TRSANSMISSION SYSTEM

Uncompensated line – types of compensation – Passive shunt, series and dynamic shunt compensation – examples.

Transient state reactive power compensation in transmission systems:

Characteristic time periods – passive shunt compensation – static compensations- series capacitor compensation –compensation using synchronous condensers – examples.

UNIT - III: REACTIVE POWER COORDINATION

Objective – Mathematical modelling – Operation planning – transmission benefits – Basic concepts of quality of power supply – disturbances- steady –state variations – effects of under voltages – frequency – Harmonics, radio frequency and electromagnetic interferences.

UNIT - IV: DEMAND SIDE MANAGEMENT

Load patterns – basic methods of load shaping – power tariffs- KVAR based tariffs, penalties for voltage flickers and Harmonic voltage levels.

Distribution side Reactive Power Management:

System losses –loss reduction methods – examples – Reactive power planning – objectives – Economics, Planning, capacitor placement – retrofitting of capacitor banks.

UNIT - V: USER SIDE REACTIVE POWER MANAGEMENT

KVAR requirements for domestic appliances – Purpose of using capacitors – selection of capacitors –deciding factors – types of available capacitor, characteristics and Limitations.

Reactive power management in electric traction systems and arc furnaces:

Typical layout of traction systems – reactive power control requirements – distribution transformers-Electric arc furnaces – basic operations- furnace transformer –filter requirements – remedial measures –power factor of an arc furnace.

LBRCE EXAM CELL Dt.............

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TEXT BOOKS

1. T.J.E.Miller, "Reactive power control in Electric power systems", John Wiley and sons, 1982
2. D.M.Tagare, "Reactive power Management", Tata McGraw Hill, 2013

REFERENCES

1. Arrillaga.J, Bradley, D.A. and Bodger. P.S., "Reactive Power Compensation", John Wiley and sons, New York, 1989.
2. R.M. Mathur: Static compensation for reactive power control, Cantext publications, Winnipeg, Canada,1984.

M.Tech.(II. Sem)

17PE16 - DSP AND FPGA PROCESSORS

L	T	P	Cr.
2	2	-	3

Pre-requisites: Microprocessors & Microcontrollers, Elements of Signal Processing
Course Educational Objective: This course enables the student to understand the architecture of digital signal processors & FPGA controllers and their programming for real time industrial applications.
Course Outcomes: At the end of the course, student will be able to:
CO1: Interpret the architectural features of digital signal processor
CO2: Analyze the addressing modes of C2xx DSP processor
CO3: Control converters using DSP processors
CO4: Analyze FPGA controller and control various power converters

UNIT – I: INTRODUCTION TO DSP
Introduction, Digital signal-processing system, the sampling process, Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT), Basic Architectural features of DSP processor TMS320LF2407, Memory Mapping.

UNIT – II: I/O & EVENT MANAGERS
Pin Multiplexing (MUX) and General Purpose I/O Overview, Peripheral interrupt expansion unit. Overview of the Event manager (EV), Compare Units, Capture Units and Quadrature Encoder Pulse (QEP) Circuit.

UNIT - III: DSP PROGRAMMING
Memory Addressing modes- Immediate addressing mode- Direct addressing mode and Indirect addressing modes. C2xx DSP CPU and Instruction Set-using assembly instruction set, Introduction to the C2xx DSP Core and Code Generation- the Components of the C2xx DSP Core -Mapping External Devices to the C2xx Core and the Peripheral Interface.

UNIT - IV: DSP-BASED IMPLEMENTATION TO POWER CONVERTERS
Introduction -Converter Structure - Continuous Conduction Mode-Discontinuous Conduction Modes of Buck, Boost converters-Connecting and controlling Buck & Boost Converters through DSP controller.

UNIT - V: FPGA-BASED SYSTEMS & APPLICATIONS
Introduction, Digital design and FPGAs-The role of FPGA, FPGA types and FPGA Vs Custom VLSI, FPGA based system design-Goals and techniques, Hierarchical design, design abstraction and methodologies, FPGA Architecture.

APPLICATIONS:
Design examples using PLDs, FPGA fabrication – logic elements, interconnect, FPGA generic design flow, FPGA partitioning, placement and routing, gate pulse generation using FPGA.

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TEXT BOOKS

1. Hamid.A.Toliyat and Steven G.Campbell,"DSP Based Electro Mechanical Motion Control ", CRC Press New York , 2004
2. Wayne Wolf," FPGA based system design ", Prentice hall, 2004

REFERENCES

1. John G. Proakis, Dimitris G. Manoiaias, “Digital Signal Processing”, Prentice Hall of India Pvt. Ltd., 3rd ed. 2000
2. J.S.Chitode, “Digital signal processing”, Technical publications pune, 1st edition,.2013.
3. TMS320LF2407 datasheets (Texas Instruments)
4. John V. Old Field, Richrad C. Dorf, Field Programmable Gate Arrays, Wiley, 2008.
5. Stephen D. Brown, Robert J. Francis, Jonathan Rose, Zvonko G. Vranesic, Field Programmable Gate Arrays, 2nd Edition, Springer, 1992.

LBRCE EXAM CELL

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M.Tech. (II Sem.)	17PE17 - APPLICATIONS OF ARTIFICIAL INTELLIGENCE TECHNIQUES	L	T	P	Cr.
		2	2	-	3

Pre-requisites: Control Systems

Course Educational Objective : This course enables the student to understand the basic principles of soft computing techniques, problem solving paradigms of ANN, fuzzy, genetic algorithms, particle Swarm Optimization & Meta-heuristics and their applications to electrical engineering.

Course Outcomes: At the end of the course, student will be able to:
CO1: Interpret different types of neural network models
CO2: Enumerate different types of fuzzification and defuzzification methods
CO3: Analyze GA, PSO and meta-heuristic techniques
CO3: Apply AI techniques to solve various engineering problems

UNIT-I: ARTIFICIAL NEURAL NETWORKS
Evolution of neural networks; Artificial Neural Network: Basic model, Classification, Feed forward and Recurrent topologies, Activation functions; Learning algorithms: Supervised, Un-supervised and Reinforcement; McCulloach – Pits model, Perceptron, Adaline, Madaline, Topology of Multi-layer perceptron, Back propagation learning algorithm, Kohenen's self-organising network: Topology, Bidirectional associative memory Topology, Hopfield network: Topology, Neural network applications in power electronics & motor drives using feedforward and recurrent architectures.

UNIT–II: FUZZY LOGIC
Introduction to classical and fuzzy sets, crisp sets, universal sets, properties of crisp sets, partition and covering, operations on crisp sets, crisp relations, operations on relations, fuzzy sets- membership function, properties of fuzzy sets, basic fuzzy set operations, fuzzy relations, operations on fuzzy relations, cardinality and relative of fuzzy relations, Fuzzification, development of rule based system, fuzzy propositions, fuzzy operators, fuzzy quantifiers, fuzzy inference, fuzzy decision making system, fuzzy ranking, defuzzification to crisp sets, defuzzification methods, control of phase controlled dc motor drive by using fuzzy logic controllers.

UNIT III: GENETIC ALGORITHM
Introduction-Basic concepts of Genetic Algorithms-Selection-Cross over-Mutation-algorithm steps-fitness function, limitations of GA, Optimization of controllers using genetic algorithm.

UNIT IV: PARTICLE SWARM OPTIMIZATION
PSO algorithm, parameter selection, Neighbourhoods and topologies, Inner workings-Convergence, Biases, Variants- Hybridization, Alleviate premature, Simplifications, Multi-objective optimization, Binary, discrete, and combinatorial, PSO applications to power converter systems.

UNIT V: META-HEURISTICS TECHNIQUES
Properties, Classification-Local search vs. Global search, Single-solution vs. Population-based, Hybridization and memetic algorithms, Parallel metaheuristics, Nature-inspired metaheuristics, meta-heuristic applications in the area of power converters.

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TEXT BOOKS

1. Jacek M. Zuarda, "Introduction to Artificial Neural Systems", Jaico Publishing House, 1999.
2. Timothy J Ross, "Fuzzy logic with engineering application", Wiley publications, Third edition, 2010.

REFERENCES

1. James A Freeman and Davis Skapura, "Neural Networks" ,Pearson Education, 2003.
2. Rajasekharan and Pai, "Neural Networks, Fuzzy logic, Genetic algorithms: synthesis and aplications" ,PHI Publication, 2003.
3. Samir Roy, Udit Chakraborty, "Introduction to Sift Computing: Neuro Fuzzy & Genetic Algorithms, Pearson Publications.
4. C.Kamalakannan, L.Padma Suresh, "Power Electronics and Renewable energy systems", Spriger, 2015
5. Devendra K.Chaturvedi, "Soft Computing: Techniques & its applications in Electrical Engineering, Springer Science.
6. B.K.Bose, "Neuran network applications in power electronics and motor drives-An introduction and perspective", IEEE transaction on Industrial Electronics, Volume 54, No 1, February, 2007.
7. Gilberto C.D.Sousa, Bimal K.Bose, "Fuzzy logic applications to power electronics and drives-An overview", IEEE conference, 1995, pages 57-62.
8. Peter Vas, "Artificial-Intellegence based electrical machines and drives", Oxford university press.
9. Naziha Ahmad Azil, Shahrinmd Ayob, Norkharzian Mohd Nayan, "Particle Swarm Optimization and its application in power converter systems", IEEE conference.
10. Susana Estefany De, Hugo Calleja, Jesus Aquayo Alquicira, "Metaheuristic optimization methods applied to power converters:A review", IEEE transaction on power electronics, volume 30, issue 12, December 2015.

LBRCE EXAM CELL

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M.Tech.(II. Sem)

17PE18 - ADVANCED MICROPROCESSORS AND MICROCONTROLLERS

L	T	P	Cr.
2	2		3

Pre-requisites: Microprocessors & Microcontrollers

Course Educational Objective: This course enables the student to illustrate the structure and instructions of advanced microprocessors like-8086/8088/80386/80486/Pentium, microcontrollers like- 8051/PIC micro controllers and their interfacings for various power electronic applications.

Course Outcomes: At the end of the course, student will be able to:
CO1: Analyze the architecture of various microprocessors
CO2: Analyze the architecture of various microcontrollers
CO3: Develop the assembly language programs for various power electronic applications
CO4: Interface various peripheral devices to processors/controllers

UNIT -I: ADVANCED PROCESSORS

Review of 8086 microprocessor, Architecture, register organization, Pin diagram, instruction set, addressing modes of 80386, 486 and Pentium Processors their memory management, Introduction to Pentium Pro Processors their features, RISC Vs CISC Processors.

UNIT- II: BASIC PERIPHERALS & THEIR INTERFACING

Memory Interfacing (DRAM), PPI- Modes of operation of 8255, interfacing to ADC, DAC, Programmable timer- 8253, PIC 8259A, Display controller, Programmable Communication Interface 8251-USART and their interfacing.

UNIT -III: MICRO CONTROLLERS

Introduction to Intel 8-bit and 16-bit Micro controllers, 8051-Architecture, memory organization, Addressing modes, Instruction formats, Instruction sets, Interrupt structure and interrupt priorities, Port structures, and Operation Linear Counter functions, Different modes of operation and programming examples.

UNIT- IV: OVERVIEW OF PIC MICROCONTROLLERS

Introduction to PIC micro controllers -Advantage of PIC micro controllers – Types and products of PIC. Applications- LCD, LED and 7 Segment Interfacing with different peripheral devices - Different types of display units.

UNIT- V: APPLICATIONS

Based on microprocessors- Sine, triangular and square wave generations, control of step- up and step- down choppers. Control of buck, boost and buck-boost converters through 8051/PIC microcontroller.

TEXT BOOKS

1. Barry b Brey, "The Intel Microprocessors, Architecture, Programming and interfacing", 8th edition, Pearson publisher, 2008.
2. Andrew N.Sloss, Dominic Symes and Chris Wright" ARM System Developer's Guide: Designing and Optimizing System Software" , 1st edition, Morgan Kaufmann Publishers, 2004.

REFERENCES

1. Steve Furber , "ARM System –On –Chip architecture", Addision Wesley, 2000.
2. Daniel Tabak , "Advanced Microprocessors", Mc Graw Hill. Inc., 2nd Edition,2012
3. James L. Antonakos , " The Pentium Microprocessor", Pearson Education, 1997.
4. Gene .H.Miller, "Micro Computer Engineering", Pearson Education , ., 3rd Edition 2003.
5. John .B.Peatman , "Design with PIC Microcontroller", Prentice Hall, 1st Edition 1997

		L	T	P	Cr.
M.Tech. (II Sem.)	**17PE62 - POWER CONVERTERS AND DRIVES-II LAB**	-	-	2	1

Pre-requisites : Power Electronics, Solid State Drives

Course Educational Objective: This course enables the student to get hands on experience in understanding power converter circuits and advanced electric drives through experimentation.

Course Outcomes: At the end of the course, student will be able to experiment

CO1: Examine the performance of various advanced drives

CO2: Design various control techniques for induction motor drive

CO3: Develop code for various converters using digital controller

LIST OF EXPERIMENTS

Hardware based:

1. DC output voltage & AC link voltage characteristics of isolated dc-dc resonant converter
2. Output voltage characteristics of dc-dc buck converter with R & RL loads using FPGA controller
3. Power factor correction of PIC Microcontroller based boost converter
4. Output voltage and current characteristics of dc-dc buck boost converter with R & RL loads
5. Output voltage and current characteristics of dc-dc forward converter with R & RL loads
6. Speed control of PM synchronous motor by voltage control method
7. Speed control of BLDC motor by voltage control method
8. Speed control of Switched Reluctance Motor with eddy current loads
9. Speed control of 3 phase Induction motor with DSP based V/f technique
10. Digital to Analog converter (DAC) and Analog to Digital converter (ADC) using digital controller

Additional Experiments

11. Generation of sinusoidal signal using digital controller
12. Generation of three phase sine triangle PWM pulses using digital controller

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M.Tech. (II Sem.)	17PE63 - SIMULATION OF POWER CONVERTERS AND DRIVES-II LAB	L	T	P	Cr.
		-	-	2	1

Pre-requisites : Power Electronics, Solid State Drives

Course Educational Objective: This course enables the student to get hands on experience in understanding power converters and advanced electric drives through simulation tools.

Course Outcomes:

At the end of the course, student will be able to:

CO1: Simulate various power electronic converters

CO2: Analyze the performance of various advanced drives using simulation tools

LIST OF EXPERIMENTS

Simulation based:

1. Power factor correction boost converter using PWM technique
2. Load voltage & current characteristics of isolated dc-dc resonant converter using PWM technique
3. Load voltage & current characteristics of dc-dc buck converter using PWM and pulse delay control techniques
4. Load & source voltage and current characteristics of dc-dc buck boost converter with R & RL loads using hysteresis PWM control technique
5. Load voltage & current characteristics of dc-dc forward converter with R & RL loads using hysteresis PWM control technique
6. Load voltage & current characteristics of dc-dc cuk converter with R & RL loads using PWM control technique
7. Load voltage & current characteristics of dc-dc fly back converter with R & RL loads using hysteresis PWM control technique
8. Speed control of PM synchronous motor by voltage control method
9. Speed control of BLDC motor by voltage control method
10. Speed control of switched reluctance motor using PWM control technique

Additional Experiments

1. Load voltage & current characteristics of push-pull dc-dc converter with R & RL loads using PWM control technique
2. Load voltage & current characteristics of full bridge dc-dc converter with R & RL loads using PWM control technique

LBRCE EXAM CELL Dt.

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		L	T	P	Cr.
M.Tech. (II Sem.)	17PE91 - INTEGRATION OF RENEWABLE SOURCES	3	--	--	3

Pre-requisites: Power Electronics, Distributed Generation

Course Educational Objective: This course enables the students to introduce the concepts of standalone and grid connected renewable energy systems with power conversion systems.

Course Outcomes: At the end of the course, student will be able to:
CO1. Characterize various renewable energy technologies and their effective utilization
CO2. Design power electronic circuits for PV-Grid integration
CO3: Design power electronic circuits for Wind-Grid integration
CO4. Analyze various energy storage systems

UNIT - I: SOLAR ENERGY
Review of Solar energy- Applications of PV Systems- Commercially available modules-switching devices for solar energy conversion - Maximum Power Point Tracking (MPPT) and Its Importance – Performance analysis for varying solar irradiance and temperature- various MPPT Techniques- - Comparison of various techniques- Charge controller and MPPT algorithms.

UNIT - II: PV BASED CONVERTER DESIGN & INTEGRATION
DC-DC Converter-Classification of DC-DC Converter- DC-AC converters- Classification of Inverters- Applications- Photo Voltaic Inverter- Grid-Tie inverter- Hybrid Inverter with batteries and grid connected system- Inverter Topologies.

UNIT - III: WIND ENERGY
Overview of Wind Energy Conversion Systems (WECS), Wind Turbine Technologies, classifications of WECS, performance of induction generators for WECS, self excited induction generator for isolated power generators, capacitance requirements, power conditioning schemes, Maximum Power Point Tracking (MPPT) Control, Synchronous Generators

UNIT - IV: WIND ENERGY BASED CONVERTER DESIGN & INTEGRATION AC Voltage Controllers (Soft Starters)- Interleaved Boost Converters- Two-Level Voltage Source Converters- Three-Level Neutral Point Clamped Converters- PWM Current Source Converters-Grid connectors concept, grid related problems, Control of Grid-Connected Inverter, .

UNIT - V: ENERGY STORAGE SYSTEMS
Energy storage parameters, Lead acid batteries-construction features-operating limits-Maintenance, Ultra capacitors-double layer capacitor-high energy capacitor-applications, Flywheels, superconducting magnetic storage system, storage heat.

TEST BOOKS

1. Farret, M. Godoy simoe, "Integration of alternative sources of energy", Wiley-IEEE Press, Dec 2005
2. Freries LL, "WInd energy conversion systems", Prentice Hall, UK.

REFERENCES

1. Chetan singh solanki, "Solar Photovoltaic Fundamentals, Technologies and Applications", PHI Learning Pvt Ltd, May 2015.
2. Van overstraeton and Mertens R.P., "Physics, Technology and use of Photovoltaics", Adam Hilger, Bristol.
3. John F.Walker &Jenkins.N, "Wind energy technology", John Wiley and sons Chichester, UK.
4. Ramesh & Kumar "Renewable Energy Technologies", Narosa publishers
5. Bin Wu, Yongqiang Lang, Navid Zargari, Samir Kouro, "Power Conversion and Control of Wind Energy Systems", Wiley-IEEE press, 2011.
6. G.N. Tiwari, "Solar Energy: Fundamentals, Design, Modeling and Applications", Narosa publisher, 2002.
7. Anjaneyulu Yerramilli, Francis Tuluri, "Energy Resources Utilization and Technologies", BS Publications, 2012.

M.Tech. (III Sem.) **17PE19 - INDUSTRIAL ELECTRONICS**

L	T	P	Cr.
2	2	-	3

Pre-requisites: Network Theory-I, Electronic Circuits and Devices

Course Educational Objective: This course enables the student to learn various industrial electronic devices, their operating principles and their applications.

Course Outcomes: At the end of the course, student will be able to:
CO1 : Identify various amplifiers used in industrial applications
CO2 : Analyze different types of timing circuits
CO3: Identify a suitable electronic device and control strategy based on application
CO4 : Differentiate between various types of transducers used in instrumentation and control systems
CO5 : Categorize various methods of electronic heating and welding mechanisms

UNIT-I :AMPLIFIERS IN INDUSTRIAL ELECTRONICS
Introduction, Direct Coupled (D.C.)Amplifiers, Resistance Coupled D.C.Amplifier, D.C.Amplifier using cathode follower, Balance Push-Pull D.C.Amplifiers, Practical D.C. Amplifiers, Chopper Amplifiers, Chopper stabilizing Amplifiers, Differential Amplifiers, Differential Amplifier using transistors.

UNIT-II: INDUSTRIAL TIMING CIRCUITS
Introduction, Classification of Timers, Thermal, Electro mechanical timer, classification of Electronic Timers-R.C.Timing Element, Digital timing Element, Time base generator, Digital counters, S.C.R.Delay Timer, I.C.Electronic Timer, Transistor Timer with Relay load control.

UNIT-III: ELECTRONIC DEVICES & CONTROL
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.

UNIT-IV: TRANSDUCERS
Introduction, Classifications of Transducers, Transducers in instrumentation and control systems, Selection of Transducers, Types of Transducers- Variable Resistance, Capacitive ,Inductive type, Piezo electric, Potentiometric Resistance, Thermistors, Pyro meters, Accelerometers, Tacho generators, Servo motors.`

UNIT-V: ELECTRONIC CONTROL OF HEATING AND WELDING
Introduction, Resistance Heating, Induction Heating, Electronic Heaters for Induction Heating, Supplies used in Induction Hearing, Dielectric Heating, Electric Welding, types-resistance and arc wilding, electric welding equipment, comparison between A.C and D.C welding.

TEXT BOOKS
1. G.K.Mithal, Ravi Mithal, "Industrial Electronics", Khanna Publishers,18th edition,1998
2. F. D. Petruzulla, "Industrial Electronics", McGraw Hill, Singapore, 1996

REFERENCES
1. S.K.Bhattacharya, S Chatterjee, "Industrial Electronics and control", PHI learning Pvt.Ltd, 5th edition,2003
2. G. M. Chute and R. D. Chute, "Electronics in Industry", McGraw Hill Ltd, Tokyo, 1995
3. Thomas E.Kissell, "Industrial Electronics Applications in Inst & proc.control, electrical machine & motion control" PHI publications,3rd edition,2003

M.Tech. (III. Sem.) **17PE20 - MICRO AND SMART GRIDS**

L	T	P	Cr.
2	2	-	3

Prerequisite: Electrical Power Transmission system, Electrical distribution system, Distributed Generation.

Course Educational Objective: This course enables the student to illustrate micro & smart grid technologies and their significance in power systems.

Course Outcomes: At the end of the course the student will be able to:
CO1: Illustrate the features of micro & smart grids
CO2: Analyze power quality problems in an electricity network
CO3: Apply the concept of distributed generation for integration with the existing power system network
CO4: Identify suitable active power controllers in power system network

UNIT-I: MICRO GRIDS
Concept and definition of microgrid, microgrid drivers and benefits, review of sources of microgrids, typical structure and configuration of a microgrid, AC and DC microgrids, Power Electronic interfaces in DC and AC microgrids, communication infrastructure, modes of operation and control of microgrid: grid connected and islanded mode, Active and reactive power control, protection issues, anti islanding schemes: passive, active and communication based techniques

UNIT-II: POWER QUALITY ISSUES IN MICROGRIDS
Introduction to Power quality issues in microgrids - Modelling and Stability analysis of Microgrid, regulatory standards, Microgrid economics, Introduction to smart microgrids.

UNIT - III: INTRODUCTION TO SMART GRID
Review of power system operation and control, Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Functions of Smart Grid, Opportunities & Barriers of Smart Grid, Difference between conventional & smart grid, Concept of Resilient & Self Healing Grid, Present development & International policies in Smart Grid. Case study of Smart Grid. CDM opportunities in Smart Grid.

UNIT- IV: SMART GRID COMMUNICATIONS AND MEASUREMENT TECHNOLOGY
Communication and Measurement - Monitoring, Phasor Measurement Unit (PMU), Smart Meters, Wide area monitoring systems (WAMS) - Advanced metering infrastructure- GIS and Google Mapping Tools, IP - based Systems, Network Architectures.

UNIT V-RENEWABLE ENERGY AND STORAGE
Renewable Energy Resources -Sustainable Energy Options for the Smart Grid -Penetration and Variability Issues associated with Sustainable Energy Technologies - Demand Response Issues - Electric Vehicles and Plug - in Hybrid Technologies -Environmental Implications - Storage Technologies - Grid integration issues of renewable energy sources

TEXT BOOKS

1. James Momoh, "Smart Grid: Fundamentals of design and analysis", John Wiley & sons Inc, IEEE press 2012.
2. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", John Wiley & sons inc, 2012.

REFERENCES

1. Stuart Borlase, "Smart Grids, Infrastructure, Technology and Solutions", CRC Press, Dec 2013.
2. Clark W.Gellings, "The smart grid: Enabling energy efficiency and demand response", Fairmont Press Inc, 2009.
3. Clark W.Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response", CRC press, 2015.

M.Tech. (III Sem.) 17PE21 - DRIVE SYSTEMS IN ELECTRIC TRACTION

L	T	P	Cr.
2	2	-	3

Pre-requisites: Electrical Machines

Course Educational Objective: This course enables the student to gain the knowledge on various motors used in the electric traction and their control mechanisms..

Course Outcomes: At the end of the course, student will be able to :

CO1: Distinguish between single and three phase traction systems

CO2: Analyze various traction mechanics

CO3: Analyze semi conductor converter controlled drives

UNIT – I: TRACTION SYSTEMS

Electric drives - Advantages & disadvantages - System of track electrification - DC, 1-Phase low frequency, 3-Phase low frequency and composite systems, Problems of 1-phase traction system - Current unbalance, Voltage unbalance, Production of harmonics, Induction effects, Booster transformer - Rail connected booster transformer. Comparison between ac and dc systems.

UNIT – II: TRACTION MECHANICS

Types of services, Speed - time curves - Construction of quadrilateral and trapezoidal speed time curves, Average & schedule speeds. Tractive effort - Speed characteristic, Power of traction motor, specific energy consumption - Factors affecting specific energy consumption, Coefficient of adhesion, slip - Factors affecting slip, magnetically suspended trains.

UNIT – III: POWER SUPPLY ARRANGEMENTS

High voltage supply, Constituents of supply system - Substations, Feeding post, Feeding & sectioning arrangements, Remote control center, Design considerations of substations, Over head equipment - principle of design of OHE, Polygonal OHE - Different types of constructions, Basic sag & tension calculations, Dropper design, Current collection gear for OHE.

UN IT – IV: TRACTION MOTORS

Desirable characteristics, D.C. and A.C. series motors, 3- Phase induction motors, linear induction motors, D.C. motor series & parallel control - Shunt bridge transition – Drum controller, Contact type bridge transition control, Energy saving, Types of braking in a.c. and d.c. drives, Conditions for regenerative braking, Stability of motors under regenerative braking, bullet trains-working principle, design aspects, hyper loop control.

UNIT – V: SEMI CONDUCTOR CONVERTER CONTROLLED DRIVES

Advantages of 25KV of AC Traction - Control of d.c. motors - single and two stage converters, Control of ac. motors - CSI fed squirrel cage induction motor, PWM VSl induction motor drive, D.C. traction — Chopper controlled d.c. motors, composite braking, Diesel electric traction - D.C. generator fed d.c. series motor, Alternator fed d.c. series motor, Alternator fed squirrel cage induction motor, Locomotive and axle codes.Introduction to new technologies in super speed electric locomotives.

TEXT BOOKS

1. Partab.H, " Modern Electric Traction", Dhanpat Rai& Sons, 2013.
2. Dubey. G.K, " Fundamentals of Electrical Drives", Narosa Publishing House - 2001.

REFERENCE:

1. C.LWadhwa,"Generation, Distribution and Utilization of Electrical Energy", New AgeInternational – 3rd edition 2015.
2. J.B. Gupta, " Utilization of Electrical Power and Electric Traction", S.K. Kataria& Sons publications, 9th edition 2013.

M.Tech. (III Sem.)

17PE22 - EMERGING TRENDS IN POWER CONVERSION TECHNOLOGIES

L	T	P	Cr.
2	2	-	3

Pre-requisites: Power Electronics

Course Educational Objective: This course enables the student to illustrate the advanced concepts of typical power electronic circuits, their topologies and control.

Course Outcomes: At the end of the course, student will be able to:

CO1: Analyze various switching techniques to reduce the harmonics

CO2: Interpret recent advancements in power converters

CO3: Analyze multilevel matrix converter and its applications

UNIT-I: SWITCHING TECHNIQUES

Gating signals – PWM techniques – Types – SPWM, SVPWM and SVM – choice of carrier frequency in SPWM – switch realization – switching losses – efficiency Vs switching frequency – applications – EMI and EMC considerations.

UNIT-II: DC – DC CONVERTERS

Basic of DC – DC converter – hard and soft switching concepts – digital switching techniques - Luo converter - principle of operation – voltage lift techniques - MPPT algorithms – sliding mode control - applications – photovoltaic systems – hybrid vehicles.

UNIT-III: ADVANCES IN INVERTERS

Multilevel concept – Diode clamped – Flying capacitor – Cascade type multilevel inverters – Hybrid multi level inverter- FFT analysis- Comparison of multilevel inverters - Applications of multilevel inverter - Principle of operation of impedance source inverter- Shoot thro zero state – Application – UPS – Adjustable speed drives.

UNIT-IV: MATRIX CONVERTER

Single phase and three phase – direct indirect – sparse and very sparse – multilevel matrix converter – Z source matrix converter – applications – wind mills – Adjustable speed drives industrial applications - Hybrid vehicles.

UNIT-V: HARMONIC MITIGATIONS

Effects of harmonics – harmonics eliminations – selective harmonic elimination – selective sine PWM carrier elimination – Power Factor controlling – active power factor controlling – hysteresis control – voltage feedback control - current feedback control.

TEXT BOOKS

1. Ned Mohan, Undeland and Robbin, "Power Electronics: Converters, Application and Design", New York, John Wiley and Sons Inc., 3rd Edition 2003.
2. R. Krishnan, "Electric Motor Drives – Modeling, Analysis and Control", New Delhi, Prentice Hall of India, 2003.

REFERENCES

1. Kolar, J.W. Schafmeister, F. Round, S.D. Ertl, H. ETH Zurich and Zurich, "Novel Three-Phase AC–AC Sparse Matrix Converters", Vol.22, No.5, IEEE Transaction on Power Electronics, Sept. 2007, pp 1649 – 1661.
2. D.M. Bellur, M.K. Kazimierczuk and O.H. Dayton, "DC-DC Converters for Electric Vehicle Applications", Conference on Electrical Insulation and Electrical Manufacturing Expo, 22-24, Oct. 2007, Nashville, USA, pp 286 – 293.
3. S. Masoud Barakati, "Applications of Matrix Converters for Wind Turbine Systems", Germany, VDM Verlag Publishers, 2008.

M.Tech. (I Sem.)	17PE23 - ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY	L	T	P	Cr.
		2	2	-	3

Prerequisite: -Nil-

Course Educational Objective: This course enables the student to learn various sources of EMI, digital circuit noises, filtering and shielding mechanisms.

Course outcomes: At the end of the course, student will be able to:
CO1: Analyze various sources of EMI and noises
CO2: Illustarte different methos of hardening
CO3: Analyze filtering and shielding mechanisms
CO4: Illustrate electrostatic discharge and its standards

UNIT-I: INTRODUCTION

Sources of EMI, Conducted and radiated interference- Characteristics - Designing for electromagnetic compatibility (EMC)- EMC regulation- typical noise path- use of network theory- methods of eliminating interferences.

UNIT-II: METHOD OF HARDENING

Cabling –capacitive coupling- inductive coupling- shielding to prevent magnetic radiation- shield transfer impedance, Grounding – safety grounds – signal grounds single point and multipoint ground systems- hybrid grounds- functional ground layout – grounding of cable shields- ground loops-guard shields

UNIT- III.:BALANCING, FILTERING AND SHIELDING

Power supply decoupling- decoupling filters-amplifier filtering –high frequency filtering & shielding – near and far fields- shielding effectiveness- absorption and reflection loss, Shielding with magnetic material- conductive gaskets, windows and coatings- grounding of shields.

UNIT-IV: DIGITAL CIRCUIT NOISE AND LAYOUT

Frequency versus time domain- analogy versus digital circuits- digital logic noise- internal noise sources- digital circuit ground noise –power distribution-noise voltage objectives measuring noise voltages-unused inputs-logic families

UNIT-V: .ELECTROSTATIC DISCHARGE&STANDARDS

Static Generation- human body model- static discharges-ED protection in equipment design- ESD versus EMC, Industrial and Government standards – FCC requirements – CISPR recommendations- Measurement methods for field strength-EMI

TEXT BOOKS

1. Henry W.Ott, " Noise reduction techniques in electronic systems", John Wiley & Sons, 2nd edition, 1989.
2. Bernhard Keiser, "Principles of Electro-magnetic Compatibility", Artech House, Inc. 1987.

REFERENCES

1. Bridges, J.E Milleta J. and Ricketts.L.W., "EMP Radiation and Protective techniques", John Wiley and sons, USA 1976.
2. IEEE National Symposium on "Electromagnetic Compatibility", IEEE, Press

M.Tech. (III Sem.) **17PE24 - INSTRUMENTATION IN ELECTRIC DRIVES**

L	T	P	Cr.
2	2	-	3

Pre-requisites: Measurements & Instrumentation, Solid State Drives

Course Educational Objective : This course enables the student to introduce industrial instruments to measure various quantities and analyse the signal behaviour and data through various techniques.

Course Outcomes: At the end of the course, student will be able to :

CO1: Identify the type of transducer used for different applications

CO2: Examine the signal behaviour through various electronic devices

CO3: Analyze measuring and sensing mechanisms for electrical and mechanical quantities

CO4: Distinguish between conventional and computerized data acquisition systems

UNIT - I :REVIEW OF TRANSDUCERS

Introduction, measurement of translational and rotational displacement. Resistive potentiometers, strain gauges; differential transformer, synchros, induction potentiometers, piezoelectric transducer; Electro-optical devices, Digital displacement transducers (Translational and rotary encoders). Magnetic and photoelectric pulse counting for speed. Transducers for Torque, voltage, current, power, frequency, power factor, and phase angle measurement.

UNIT – II:SIGNAL CONDITIONING

Necessity, Instrumentation amplifiers, chopper stabilized amplifiers, Impedance converters, Noise problems, shielding and grounding. Concept of filters; Low pass filters; high pass filters; band pass filters ;band rejection filters; digital filters. Integration and differentiation of signals, Dynamic compensation, Linearization, Concept of A/D and D/A Converters (voltage to frequency and frequency to voltage converter) sample/hold amplifiers, Microprocessor applications in signal conditioning.

UNIT – III:DATA TRANSMISSION AND RECORDING

Cable transmission of analog voltage and current signals, cable transmission of digital data, Fiber optic data transmission, FM radio telemetry, synchro position repeater systems.

UNIT – IV:MEASUREMENT AND SENSING IN SOLID STATE DRIVES

Measurement techniques in DC and AC drives recording of waveforms- Microprocessor based measurement of frequency, phase angle; power factor; voltage; current; reactance; resistance; kVA; kW; kWh and kVAr. Sensing: sensing of voltage, current, Power and speed.

UNIT – V:COMPUTERIZED DATA ACQUISITION SYSTEM

Elements of data acquisition systems, data loggers, instrument interconnection systems; Block diagram and details of computerized data acquisition systems, Instrumentation schemes for close loop control of DC and AC drives.

TEXT BOOKS

1. Jones, B.E., "Instrument Technology", Tata McGraw Hill, New Delhi, 1987
2. Andrew Parr, "Industrial Control Handbook", Newness Industrial press, New Delhi, 1998

REFERENCES

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