PG Course Structure-R20 (PED)

I SEMESTER

S.No.	Course code	Course Title	Contact hours/week			Credits	Scheme of Valuation		
			L	T	P		CIE	SEE	Total
Theory Courses									
1	20PE01	Analysis Of Power Converters	2	1	-	3	40	60	100
2	20PE02	Control of Motor Drives-I	2	1	-	3	40	60	100
3	**PROGRAM ELECTIVE – I**		3	-	-	3	40	60	100
	20PE03	Power Quality							
	20PE04	FACTS							
	20PE05	HVDC Systems							
4	**PROGRAM ELECTIVE – II**		3	-	-	3	40	60	100
	20PE06	Modern Control Theory							
	20PE07	Machine Modelling and Analysis							
	20PE08	Meta Heuristics Optimization Techniques							
5	20RM01	Research Methodology and IPR	2	-	-	2	40	60	100
6	**Audit Course-I**		2	-	-	0	100	-	100
Laboratory Courses									
7	20PE61	Power Converters & Drives-I Lab	-	-	4	2	40	60	100
8	20PE62	Simulation of Power Converters & Drives-I Lab	-	-	4	2	40	60	100
Total			14	02	08	18	380	420	800

II SEMESTER

S.No	Course code	Course Title	Contact hours/week			Credits	Scheme of Valuation		
			L	T	P		CIE	SEE	Total
Theory Courses									
1	20PE09	Switched Mode Power Converters	2	1	-	3	40	60	100
2	20PE10	Control of Motor Drives-II	2	1	-	3	40	60	100
3	**PROGRAM ELECTIVE – III**		3	-	-	3	40	60	100
	20PE11	Artificial Intelligent Techniques & Applications							
	20PE12	Emerging Trends in Power Converter Technologies							
	20PE13	Micro and Smart Grid Technologies							
4	**PROGRAM ELECTIVE – IV**		3	-	-	3	40	60	100
	20PE14	Hybrid Electrical Vehicles							
	20PE15	Wind Energy Conversion Technologies							
	20PE16	Electro Magnetic Interference and Compatibility							
5	**Audit course-II**		2	-	-	0	100	-	100
Laboratory Courses									
6	20PE63	Power Converters & Drives-II Lab	-	-	4	2	40	60	100
7	20PE64	Simulation of Power Converters & Drives -II Lab	-	-	4	2	40	60	100
8	20PE51	Mini Project	-	-	4	2	100	-	100
Total			12	02	12	18	440	360	800

III SEMESTER

<table>
<tr><th rowspan="2">S.No</th><th rowspan="2">Course code</th><th rowspan="2">Course Title</th><th colspan="3">Contact hours/week</th><th rowspan="2">Credits</th><th colspan="3">Scheme of Valuation</th></tr>
<tr><th>L</th><th>T</th><th>P</th><th>CIE</th><th>SEE</th><th>Total</th></tr>
<tr><td colspan="10">Theory Courses</td></tr>
<tr><td rowspan="4">1</td><td colspan="2">PROGRAM ELECTIVE – V</td><td rowspan="4">3</td><td rowspan="4">-</td><td rowspan="4">-</td><td rowspan="4">3</td><td rowspan="4">40</td><td rowspan="4">60</td><td rowspan="4">100</td></tr>
<tr><td>20PE17</td><td>DSP & FPGA Controllers</td></tr>
<tr><td>20PE18</td><td>Advanced Microprocessors & Microcontrollers</td></tr>
<tr><td>20PE19</td><td>Advanced Power Semiconductor Devices & their protection</td></tr>
<tr><td>2</td><td>OE</td><td>Open Elective/MOOCS</td><td>3</td><td>-</td><td>-</td><td>3</td><td>40</td><td>60</td><td>100</td></tr>
<tr><td>3</td><td>20PE52</td><td>Internship</td><td>-</td><td>-</td><td>4</td><td>2</td><td>100</td><td>-</td><td>100</td></tr>
<tr><td>4</td><td>20PE53</td><td>Project Work & Dissertation (Phase-I)</td><td>-</td><td>-</td><td>16</td><td>8</td><td>40</td><td>60</td><td>100</td></tr>
<tr><td colspan="3">Total</td><td>6</td><td>-</td><td>20</td><td>16</td><td>220</td><td>180</td><td>400</td></tr>
</table>

IV SEMESTER

<table>
<tr><th rowspan="2">S.No</th><th rowspan="2">Course code</th><th rowspan="2">Course Title</th><th colspan="3">Contact hours/week</th><th rowspan="2">Credits</th><th colspan="3">Scheme of Valuation</th></tr>
<tr><th>L</th><th>T</th><th>P</th><th>CIE</th><th>SEE</th><th>Total</th></tr>
<tr><td colspan="10">Theory Courses</td></tr>
<tr><td>1</td><td>20PE54</td><td>Project Work & Dissertation (Phase-II)</td><td>-</td><td>-</td><td>32</td><td>16</td><td>40</td><td>60</td><td>100</td></tr>
<tr><td colspan="3">Total</td><td>-</td><td>-</td><td>32</td><td>16</td><td>40</td><td>60</td><td>100</td></tr>
</table>

Total Credits: 18 + 18 + 16 + 16 = 68

AUDIT COURSES		
S.No	**Code**	**Name of the Course**
1	20AC01	English for research paper writing
2	20AC02	Disaster Management
3	20AC03	Sanskrit for Technical Knowledge
4	20AC04	Value education
5	20AC05	Constitution of India
6	20AC06	Pedagogy Methods
7	20AC07	Stress Management by Yoga
8	20AC08	Personality Development through Life Enlightenment Skills.

List of Open Elective Courses offered to other Departments

S.No	Code	Open Elective Name
1	20PE81	Energy Management
2	20PE82	Power Converters
3	20PE83	Renewable Energy Systems

20PE01- ANALYSIS OF POWER CONVERTERS

M.Tech. (I Sem.)

L	T	P	Cr.
2	1	--	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: Analyze the performance of controlled rectifiers
CO2: Understand the operation of dc choppers
CO3: Analyze the performance of ac voltage controller and inverters
CO4: Illustrate the operation of various multi level inverters.

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, modular multilevel converter.

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.

20PE02-CONTROL OF MOTOR DRIVES - I

M.Tech. (I Sem.)

L	T	P	Cr.
2	1	--	3

Pre-requisites : Power Electronics and Solid State Drives

Course Educational Objective : This course enables the student toprovide 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 -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.

<u>TEXT BOOKS</u>

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.

REFERENCE BOOKS

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.

4. Bimal K. Bose, "Power Electronics and Motor Drives: Advances and Trends", Elsevier, 2006.

M.Tech. (I Sem.)

20PE03-POWER QUALITY

L	T	P	Cr.
3	-	--	3

Pre-requisites **:** Power Systems and 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: Typical wiring and grounding problems, solutions to wiring and grounding problems in the context of power quality.

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.

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.Tech. (I Sem.)

20PE04-FACTS

L	T	P	Cr.
3	--	--	3

Pre-requisites: Power Electronics and Power Systems

COURSE EDUCATIONAL OJECTIVES: This course enables the student to analyze various FACTS controllers and mitigating the reactive power.

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

CO1. Illustrate the various FACTs controllers

CO2. Analyze series and shunt compensation

CO3. Understand the importance of voltage regulators

CO4. Analyze the concepts of UPFC

UNIT – I: INTRODUCTION

FACTS Concepts: Transmission interconnections power flow in an AC system, loading capability limits, Dynamic stability considerations, importance of controllable parameters, basic types of FACTS controllers, benefits from FACTS controllers.

UNIT – II: SHUNT COMPENSATION

Principles of shunt compensation – Variable Impedance type & switching converter type- Static Synchronous Compensator (STATCOM) configuration, characteristics and control.

UNIT –III :SERIES COMPENSATION

Principles of static series compensation using GCSC, TCSC and TSSC, Static Synchronous Series Compensator (SSSC).

UNIT – IV: VOLTAGE REGULATORS

Principles of operation-Steady state model and characteristics of a static voltage regulators and phase shifters- power circuit configurations.

UNIT – V: UNIFIED POWER FLOW CONTROLLER (UPFC)

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.

TEXT BOOKS

1. N.G.Hingorani&L.Gyugyi, *Understanding FACTS*: *Concepts and Technology of Flexible AC Transmission Systems,* IEEE Press, 1999.

2. X.P. Zang, C. Rehtanz and B. Pal, *Flexible AC Transmission Systems: Modelling and Control*, Birkhauser, 2006.

REFERENCE BOOKS

3. Y. H. Song and A. T. Johns, *Flexible AC Transmission Systems*, IET, 1999.

20PE05-HVDC SYSTEMS

M.Tech. (I Sem.)

L	T	P	Cr.
3	--	--	3

Pre-requisites: Power Electronics

COURSE EDUCATIONAL OJECTIVES: This course enables the student to illustrateHVDC transmissiontechnologies, 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. Understand the converters used in HVDC transmission system

CO3: Identify various faults in converter station

CO4: Analyze the concepts of harmonics and filters

UNIT – I: HVDC Basic Concepts

Economics & Terminal equipment of HVDC transmission systems: Types of HVDC Links – Schematics of HVDC Station – Comparison of AC &DC Transmission, Applications of DC Transmission and problems -Modern trends in D.C. Transmission, Ground return- advantages.

UNIT – II: Converter Theory and Performance

Valve characteristics, converter configuration, analysis of 6-pulse converters and 2-pulse converters, converter transformer rating, Mmultiple bridge converter, current source converter, MultiterminalD.C (M.T.D.C) systems and types

UNIT – III: Control of HVDC System

Basic principle of control, Hierarchy of controls,control implementation, starting, stopping andpower flow reversal, Converter firing controlschemes -Constant α control, Inverse cosine control

UNIT – IV: Converter Faults & Protection

Converter fault types-D.C fault, A.C fault– protection against over-current and over-voltage in converter station – surge arresters –smoothing reactors – DC breakers.

UNIT – V: Harmonics and Filters

A.C and D.C side Harmonics –Characteristic harmonics Non- Characteristic harmonics, adverse effects of harmonics, Types of AC filters, D.C filters.

TEXT BOOKS

1. K.R.Padiyar,HVDC Power Transmissions Systems: Technology and system interactions, New Age International (P) Ltd.

2. S Kamakshaiah, V Kamaraju: HVDC Transmission,*Tata Mcgraw Hill* Education Private Limited, Ist.Edition

REFERENCES

1. J Arrillaga, High Voltage Direct current Transmission, Peter Peregrinus Ltd, UK.

2. E.W.Kimbark, Direct Current Transmission, Wiley-Interscience, New York.

20PE06-MODERN CONTROL THEORY

M.Tech. (I Sem.)

L	T	P	Cr.
3	--	--	3

Prerequisite: Control systems

Course Educational Objective: This course enables the studentto 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– Krasovskiiand 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

20PE07-MACHINE MODELING AND ANALYSIS

M.Tech. (I Sem.)

L	T	P	Cr.
3	--	--	3

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 αβ0) and two phase to three phase transformation (αβ0 to abc) --Power equivalence-Modeling of 1-Phase induction motor-cross field theory-mathematical modeling 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, modeling of BLDC motor, modeling 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

REFERENCE BOOKS
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.

20PE08-META HEURISTICS OPTIMIZATION TECHNIQUES

M.Tech. (I Sem.)

L	T	P	Cr.
3	--	--	3

Pre-requisites: Engineering Mathematics

Course Educational Objective: This course enables the student toillustrate 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 optimization techniques for engineering systems

CO4: Apply the 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", 4theEdition, 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", 4thEdn., 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 NovickiObadowski, 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 SheerazKirmani, "Implementation of Gentetic Algorithm to find the optimal timing of Overcurrent relays", IEEE conference, 2016.

20RM01-RESEARCH METHODOLOGY and IPR

M.Tech. (I Sem.)

L	T	P	Cr.
2	--	--	2

Pre-requisites: Knowledge in Engineering, English

Course Objective: To understand the research problem, to know the literature studies, plagiarism and ethics ,to get the knowledge about technical writing ,to analyse the nature of intellectual property rights and new developments and research related information and to know the patent rights

Course Outcomes: After the completion of the course, students should be able to

CO1 Analyze the research problem and its formulation.

CO2 Analyze the significance of research ethics

CO3 Apply the information technology for better tomorrow and to develop creativity.

CO4 Identify the importance of intellectual property rights to be promoted among students in general & engineering in particular

CO5 Describe the IPR protection for new and better products, and in turn brings about, economic growth and social benefits.

UNIT I- RESEARCH PROBLEM AND SCOPE FOR SOLUTION

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

UNIT II- FORMAT

Effective literature studies approaches, analysis, Plagiarism, Research ethics. Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

UNIT III- PROCESS AND DEVELOPMENT

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, patenting under PCT.

UNIT IV- PATENT RIGHTS

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

UNIT V- NEW DEVELOPMENTS IN IPR

New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

TEXT BOOKS

1. Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science & engineering students”
2. Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”
3. Ranjit Kumar, 2nd Edition, “Research Methodology: A Step by Step Guide for beginners”

REFERENCES

1. Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd ,2007.
2. Mayall, “Industrial Design”, McGraw Hill, 1992.
3. Niebel, “Product Design”, McGraw Hill, 1974.
4. Asimov, “Introduction to Design”, Prentice Hall, 1962.
5. Robert P. Merges, Peter S. Menell, Mark A. Lemley, “ Intellectual Property in New Technological Age”, 2016.
6. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008

20PE61-Power Converters and Drives-I Lab

M.Tech. (I Sem.)

L	T	P	Cr.
-	-	4	2

Pre-requisites : Power Electronics and Solid State Drives

Course Educational Objective: This course enables the student toget 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 motor drives using hardware controllers

CO2: Control AC motor drives using hardware controllers

CO3: Examine the characteristics of power electronic devices

CO4: Analyze the performance of different power electronic converters using hardware controllers

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

<u>Additional Experiments</u>

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

M.Tech. (I Sem.)

20PE62-Simulation of Power Converters & Drives-I Lab

L	T	P	Cr.
-	-	4	2

Pre-requisites : Power Electronics and Solid State Drives
Course Educational Objective : This course enables the student toget hands on experience on various power semiconductor devices, converter circuits and drives usingsimulation 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 drives using software tools

CO4: Design and control 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 driveusing 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 and SVPWM techniques
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 v/f controltechnique

20PE09-SWITCHED MODE POWER CONVERSION

M.Tech. (II Sem.)

L	T	P	Cr.
2	1	--	3

Pre-requisites : Power Electronics

Course Educational Objective: This course enables the student tounderstand principles andbasic topologies of switched mode power converters.

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

CO1: Identifyvarious types of switched mode converter topologies

CO2: Analyze various DC-DC converter topologies

CO3: Illustrate soft switching techniques

CO4: Analyze different types of power factor correction circuits

UNIT-I:NON ISOLATED SWICHMODE POWER CONVERTERS

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

UNIT-II: ISOLATED SWICHMODE POWER CONVERTERS

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.

20PE10-CONTROL OF MOTOR DRIVES - II

M.Tech. (II Sem.)

L	T	P	Cr.
2	1	--	3

Pre-requisites **:** Power Electronics and Solid State Drives

Course Educational Objective: This course enables the student toillustratethe 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 synchronous motor drive with different controlling strategies
CO3: Control SRM drive with different controlling strategies
CO4: Analyze the controlling of BLDC and Linear motors with different controlling strategies

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 Schemes- 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, soft starters

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.

REFERENCE BOOKS

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

20PE11-ARTIFICIAL INTELLIGENCE TECHNIQUES & ITS APPLICATIONS

M.Tech. (II Sem.)

L	T	P	Cr.
3	--	--	3

Pre-requisites **:** Control Systems

Course Educational Objective : This course enables the student tounderstand 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

CO4: 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-organizing network: Topology, Bidirectional associative memory Topology, Hopfield network: Topology, Neural network applications in power electronics & motor drives using feed forward 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.

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, ShahrinmdAyob, NorkharzianMohdNayan, “Particle Swarm Optimization and its application in power converter systems”, IEEE conference.
10. Susana Estefany De, Hugo Calleja, Jesus AquayoAlquicira, “Metaheuristic optimization methods applied to power converters:A review”, IEEE transaction on power electronics, volume 30, issue 12, December 2015.

20PE12-EMERGING TRENDS IN POWER CONVERTER TECHNOLOGIES

M.Tech. (II Sem.)

L	T	P	Cr.
3	-	--	3

Pre-requisites **:**Power Electronics

Course Educational Objective : This course enables the student toillustratethe 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: Illustrate various switching techniques

CO2: Analyze the operation of different dc-dc and dc-ac converters

CO3: Understand the operation of matrix converters

CO4: Analyze various sources of harmonics and its mitigation

Unit-1: 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.

Reference Books:

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.

20PE13-MICRO AND SMART GRID TECHNOLOGIES

M.Tech. (II. Sem.)

L	T	P	Cr.
3	--	--	3

Prerequisite: Power systems
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, antiislanding 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 HybridTechnologies -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 & sonsInc, IEEE press 2012.

2. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, “Smart Grid: Technology and Applications”, John Wiley & sons inc, 2012.

REFERENCE BOOKS:

1. Stuart Borlase, “Smart Grids, Infrastructure, Technology and Solutions”, CRC Press, Dec2013.
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. (II Sem.)

20PE14-HYBRID ELECTRICAL VEHICLES

L	T	P	Cr.
3	--	--	3

Pre-requisites **:** Control systems, Power Electronics and 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

CO4 : Control various drives used in 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 WenzhongGao , “Hybrid Electrical Vehicle Principles and Application with Practical Perspectives”.

20PE15-WIND ENERGY CONVERSION TECHNOLOGIES

M.Tech. (II Sem.)

L	T	P	Cr.
3	--	--	3

Prerequisites: Electrical Machines and Power Electronics
Course Objective: This course enables the student to gain knowledge on various wind energy conversion systems and converter topologies for extracting power from wind systems.

Course Outcomes: At the end of the course, student will be able to:
CO1: Illustrate basic components of wind energy system
CO2: Analyze wind turbine technologies
CO3: Understand the operation of wind energy conversion systems
CO4: Analyze modelling and controlling of DFIG

UNIT - I: Introduction
Wind Energy Basics, Wind Speeds and scales, Terrain, Roughness, Wind Mechanics, Power Content, Class of wind turbines, Atmospheric Boundary Layers, Turbulence, Wind Measurements, Analysis and Energy Estimates, Instrumentation for wind measurements, Wind data analysis, tabulation, Wind resource estimation, Betz's Limit, Turbulence Analysis
Unit II: Wind Turbines Technology-I
Wind turbines types: Vertical Axis Type, Horizontal Axis, Constant Speed Constant Frequency, Variable speed Variable Frequency, Up Wind, Down Wind, Stall Control , Pitch Control, Gear Coupled Generator type, Direct Generator Drive /PMG/Rotor Excited Sync Generator Wind Turbine Technology & Components of WTG - Gear Coupled Generator Type for Const. Speed- Direct Coupled Generator Type [Variable Speed Variable Frequency]: Multipole Synchronous / PMG Generators.
Unit III: Wind Turbines Technology-II
Gear Coupled Generator Wind Turbine Components and their construction Electronics Sensors /Encoder /Resolvers, Wind Measurement : Anemometer & Wind Vane, Grid Sysnchronisation System, Soft Starter, Switchgear [ACB/VCB], Transformer, Cables and assembly, Compensation Panel, Programmable Logic Control, UPS, Yaw & Pitch System : AC Drives, Safety Chain Circuits, Generator Rotor Resistor controller (Flexi Slip), Differential Protection Relay for Generator
UNIT - IV: Wind Energy Conversion Systems
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 - V: Modeling, Operation and Control of DFIG
DFIG Based Wind Energy Conversion System, Steady-State Equivalent Circuit, Reactive Power Control-Reactive Power Sources, Optimum Reactive Power Distribution, Transient Models And Control Of DFIG- Power Converter Controls, Rotor Side Converter Control, Current Regulator Control, Grid Side Converter Control.

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.

20PE16-ELECTRO MAGNETIC INTERFERENCE AND COMPATIBILITY

M.Tech. (II Sem.)

L	T	P	Cr.
3	--	--	3

Prerequisite: -Nil-

Course Educational Objective: This course enables the studentto 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 methods 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

<u>TEXT BOOKS</u>

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.

REFERENCE BOOKS

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

20PE63-Power Converters and Drives-II Lab

M.Tech. (II Sem.)

L	T	P	Cr.
-	-	4	2

Pre-requisites **:** Power Electronics and Solid State Drives

Course Educational Objective: This course enables the student toget 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

CO1: Analyze the performance of various power converters

CO2: Control the speed of PMSM and BLDC motors using digital controllers

CO3: Control the speed of SRM and 3-phase induction motors using digital controllers

CO4: Develop code for different applications using digital controllers

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

<u>Additional Experiments</u>

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

M.Tech. (II Sem.)

20PE64-Simulation of Power Converters & Drives-II Lab

L	T	P	Cr.
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Pre-requisites : Power Electronics and Solid state Drives

Course Educational Objective: This course enables the student toget 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: Analyze the performance of various power converters using simulation tools

CO2: Control the speed of PMSM and BLDC motors using simulation tools

CO3: Control the speed of SRM and 3-phase induction motors 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

<u>Additional Experiments</u>

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

20PE17-DSP & FPGA CONTROLLERS

M.Tech.(III. Sem)

L	T	P	Cr.
3	--	-	3

Pre-requisites: Microprocessors and Microcontrollers and Elements of Signal Processing

Course Educational Objective: This course enables the student tounderstandthe 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.

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.

20PE18-ADVANCED MICROPROCESSORS & MICROCONTROLLERS

M.Tech.(III. Sem)

L	T	P	Cr.
3	--	--	3

Pre-requisites **:** Microprocessors & Microcontrollers

Course Educational Objective: This course enables the student toillustrate 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 CommunicationInterface 8251-USART and their interfacing.

UNIT-III: MICRO CONTROLLERS

Introduction to Intel 8-bit and 16-bit Micro controllers, 8051-Architecture, memoryorganization, 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, boostand buck-boost convertersthrough 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

20PE19-ADVANCED POWER SEMICONDUCTOR DEVICES & THEIR PROTECTION

M.Tech.(III Sem)

L	T	P	Cr.
3	-	-	3

Pre-requisites **:** Electronic Circuits & Devices and Power Electronics

Course Educational Objective : This course enables the student tounderstandswitching 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: Illustrate various protection circuits

CO3: Develop gate driver circuits for power semiconductor devices

CO4: Understand different passive components and noise sources

UNIT- I: BJTS&MOSFETS

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

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

UNIT -II: IGBTs & IGCTs

IGBTs:Introduction-basic structures-I-V characteristics-physics of device operation-Latch in IGBTsswitchingcharacteristics-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) switchingcharacteristics-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 switchingcharacteristics-snubber circuits-over protection of GTOs-Power junction field effect transistors-field controlled Thyristor-JFET baseddevices versus other power devices-MOS controlled Thyristors-high voltage integratedcircuits-new semiconductor materials

UNIT -IV: PASSIVE COMPONENTS, ELECTROMAGNETIC COMPATIBILITY AND NOISE

Introduction-design of inductor-transformer design-selection of capacitors-resistors currentmeasurements-heat sinking circuit lay out –Electromagnetic Interference (EMI)-Sources ofEMI-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 powerswitching devices- snubber circuits –Reverse recovery transients – Supply and load side transients – voltage protections – current protections- commercially available power semiconductor devices and their ratings.

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.

Reference books

1. Md.H.Rashid "Power Electronics", Pearson Education, 4th edition, 2014.

2.. Vithayathil, " Power Electronics Circuits", Mcgraw Hill Education, 1st edition, 2010