E.G.S. PILLAY ENGINEERING COLLEGE

(Autonomous)

Approved by AICTE, New Delhi | Affiliated to Anna University, Chennai
Accredited by NAAC with 'A' Grade | Accredited by NBA (CSE, EEE, MECH)
NAGAPATTINAM – 611 002

M.E. POWER ELECTRONICS AND DRIVES

Full Time Curriculum and Syllabus

First Year – First Semester

Course Code	Course Name	L	T	P	C	Maximum Marks		
						CA	ES	Total
Theory Course								
1701PE101	Applied Mathematics for Electrical Engineers	2	2	0	3	40	60	100
1702PE102	Power Semiconductor Devices and Recent Advancements	3	0	0	3	40	60	100
1702PE103	Analysis of Power Converters	3	2	0	4	40	60	100
1702PE104	Analysis of Inverters	3	2	0	4	40	60	100
1702PE105	Modelling and Analysis of Electrical Machines	3	2	0	4	40	60	100
	Elective-I	3	0	0	3	40	60	100
Laboratory Course								
1704PE106	Power Electronic Circuits Laboratory	0	0	2	1	50	50	100
1704PE107	Power Electronics Simulation Laboratory	0	0	2	1	50	50	100
1704PE108	Communication Skills Lab I	0	0	2	1	100	0	100

First Year – Second Semester

Course Code	Course Name	L	T	P	C	Maximum Marks		
						CA	ES	Total
Theory Course								
1701PE201	Research Methodology	3	0	0	3	40	60	100
1702PE202	Solid State DC Drives	3	0	0	3	40	60	100
1702PE203	Solid State AC Drives	3	0	0	3	40	60	100
1702PE204	Power Quality Issues and Solutions	3	0	0	3	40	60	100
1702PE205	Modelling and Design of SMPS	3	0	0	3	40	60	100
	Elective-II	3	0	0	3	40	60	100
Laboratory Course								
1704PE206	Electrical Drives Laboratory	0	0	2	1	50	50	100
1704PE207	Technical Seminar	0	0	2	1	100	0	100
1704PE208	Communication Skills Lab II	0	0	2	1	100	0	100

Second Year – Third Semester

Course Code	Course Name	L	T	P	C	Maximum Marks		
						CA	ES	Total
Theory Course								
	Elective-III	3	0	0	3	40	60	100
	Elective-IV	3	0	0	3	40	60	100
	Elective-V	3	0	0	3	40	60	100
Laboratory Course								
1704PE301	Project Work (Phase I)	0	0	12	6	50	50	100

Second Year – Fourth Semester

Course Code	Course Name	L	T	P	C	Maximum Marks		
						CA	ES	Total
Laboratory Course								
1704PE401	Project Work (Phase II)	0	0	24	12	50	50	100

Electives

Course Code	Course Name	L	T	P	C	Maximum Marks		
						CA	ES	Total
Programme Elective Courses								
1703PE001	Recent Trends in Power Conversion Technology	3	0	0	3	40	60	100
1703PE002	Power Converters for Solar and Wind Energy Conversion System	3	0	0	3	40	60	100
1703PE003	Digital Controllers In Power Electronic Applications	3	0	0	3	40	60	100
1703PE004	Nonlinear Dynamics for Power Electronic Circuits	3	0	0	3	40	60	100
1703PE005	Industrial Control Electronics	3	0	0	3	40	60	100
1703PE006	Applications of Power Electronics in Utility Systems	3	0	0	3	40	60	100
1703PE007	Special Electrical Machines & Controllers	3	0	0	3	40	60	100
1703PE008	Advanced Control of Electric Drives	3	0	0	3	40	60	100
1703PE009	SCADA System and Applications Management	3	0	0	3	40	60	100
1703PE010	Distributed Generation and Micro grids	3	0	0	3	40	60	100
1703PE011	Electric Vehicles and Power Management	3	0	0	3	40	60	100
1703PE013	Micro Electro Mechanical Systems (MEMS)	3	0	0	3	40	60	100
1703PE014	Modern HVDC Transmission	3	0	0	3	40	60	100
1703PE015	Electromagnetic Field Computation and Modeling	3	0	0	3	40	60	100
1703PE016	Electromagnetic Interference and Compatibility	3	0	0	3	40	60	100
1703PE017	Modern Rectifiers and Resonant Converters	3	0	0	3	40	60	100
1703PE018	Optimization Techniques	3	0	0	3	40	60	100
1703PE019	Power System Restructuring and Pricing	3	0	0	3	40	60	100
Open Elective Courses								
1703PE020	Energy Management and Auditing	3	0	0	3	40	60	100
1703PE021	Computer Aided Design of Power Electronics Circuits	3	0	0	3	40	60	100
1703PE022	Renewable energy technology	3	0	0	3	40	60	100
1703PE023	Optimization Techniques	3	0	0	3	40	60	100
1703PE020	Soft Computing Techniques for Renewable Energy System	3	0	0	3	40	60	100

L – Lecture | T – Tutorial | P – Practical | C – Credit | CA – Continuous Assessment | ES – End Semester

1701PE101 APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERS

L	T	P	C
2	2	0	3

COURSE OBJECTIVES:

1. To achieve an understanding of the basic concepts of one dimensional and two dimensional random variables and apply it in electrical engineering problems.
2. To develop the ability to apply the concepts of Linear programming in Electrical Engineering problems.
3. To familiarize the students in Fourier series and solve problems using Fourier transforms associated with engineering applications.

UNIT I ONE DIMENSIONAL RANDOM VARIABLES 9 Hours

Random variables - Probability function – moments – moment generating functions and their properties – Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions – Function of a Random Variable.

UNIT II TWO DIMENSIONAL RANDOM VARIABLE 9 Hours

Joint distributions – Marginal and conditional distributions – Covariance – Correlation and Linear regression – Transformation of random variables.

UNIT III INTRODUCTION TO LINEAR PROGRAMMING (LP) 9 Hours

Introduction to applications of operations research in functional areas of Engineering, Linear Programming-formulation, solution by graphical and simplex methods (Primal - Penalty, Two Phase), Special cases. Dual simplex method. Principles of Duality. Sensitivity Analysis.

UNIT IV INVENTORY MODELS, SIMULATION AND DECISION THEORY 9 Hours

Inventory Models – EOQ and EBQ Models (With and without shortages), Quantity Discount Models. Decision making under risk – Decision trees – Decision making under uncertainty. Monte-carlo simulation.

UNIT V FOURIER SERIES 9 Hours

Fourier Trigonometric series: Periodic function as power signals – Convergence of series – Even and odd function: cosine and sine series – Non-periodic function: Extension to other intervals - Power signals: Exponential Fourier series – Parseval's theorem and power spectrum – Eigen value problems and orthogonal functions – Regular Sturm – Liouville systems – Generalized Fourier series.

TOTAL: 45 HOURS

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

CO1: Obtain Random variables corresponding to random experiments and able to calculate the distributions for functions of random variables

CO2: Compute Expected value and higher order moments of random variables for two dimensional random variable

CO3: Apply the mathematical tools that are needed to solve optimization problems

CO4: Apply Inventory models in making simulations

CO5: Apply Fourier series in solving real time problems in power signals and spectrum

REFERENCES:

1. Grewal, B.S., Higher Engineering Mathematics, 42nd edition, Khanna Publishers, 2012.
2. O'Neil, P.V., Advanced Engineering Mathematics, Thomson Asia Pvt. Ltd., Singapore,2003.
3. Hamdy A Taha, Introduction to Operations Research, Prentice Hall India, Seventh Edition, Third Indian Reprint 2004.
4. G. Srinivasan, Operations Research – Principles and Applications, PHI, 2007.
5. Gupta P.K, Hira D.S, Problem in Operations Research, S.Chand and Co, 2007.
6. Kalavathy S, Operations Research, Second Edition, Vikas Publishing House, 2004
7. Oliver C. Ibe, "Fundamentals of Applied Probability and Random Processes, Academic Press, (An imprint of Elsevier), 2010
8. Andrews L.C. and Phillips R.L., Mathematical Techniques for Engineers and Scientists, Prentice Hall of India Pvt.Ltd., New Delhi, 2005

1702PE102	POWER SEMICONDUCTOR DEVICES AND RECENT ADVANCEMENTS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To understand the basic concepts of power semiconductor devices.
2. To analyze the characteristics of various devices
3. To design a power electronic circuit for an application.

UNIT I INTRODUCTION **9 Hours**

Status of development of power semiconductor Devices – Types of static switches – Controlled and uncontrolled – Ideal and real switches – Static and dynamic performance – Use of heat sinks – Switching losses.

UNIT II POWER DIODES **9 Hours**

Types – Electrical rating – Switching and steady state characteristics – Snubber circuits – Series and parallel operation – Schottly diodes – Fast recovery diodes.

UNIT III THYRISTORS **9 Hours**

Physics of device operation – Electrical rating - Switching and steady state characteristics – Gate circuit requirements – Protection – Series and parallel operation – Driver circuit – Types of thyristors: Asymmetrical thyristor – Reverse conducting Thyristor – Light fired thyristor – Switching losses - TRIACs, GTOs and MCTs - Electrical rating - Switching and steady state characteristics – Protection – Gate circuit requirements.

UNIT IV POWER TRANSISTORS **9 Hours**

Types – Ratings – Static and switching characteristics – Driver circuit – Snubber circuits – Power Darlington - Power MOSFETs -Types – Comparison with BJTs – Structure – Principle of operation – Switching losses – Driver circuit – Snubber circuits.

UNIT V IGBTS AND MODERN POWER DEVICES **9 Hours**

Comparison with power BJT and MOSFET – Structure – Principle of working – Switching characteristics – Gate drive requirements – HV IGBT structure – Principle of working – Comparison with GTO -SITs – Characteristics – Power integrated circuit – Characteristics – Field controlled thyristors – New semiconductor materials for devices – Intelligent power modules. Integrated gate commutated thyristor (IGCT) - Comparison of all power devices.

TOTAL: 45 HOURS

FURTHER READING:

Application of Power Devices in Power System Protection Circuits.

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

CO1: Explain the recent developments in Power Semiconductor Devices.
CO2: Describe the construction and working features of Power Devices like power diodes, thyristors, power transistors and IGBTs.
CO3: Explain the characteristics of power semiconductor devices.
CO4: Explain the switching losses present in the devices.
CO5: Explain and apply protection circuit for each device.

REFERENCES:

1. Joseph Vithayathil, *Power Electronics: Principles and Applications*, Delhi, Tata McGraw-Hill, 2010.
2. Ned Mohan, Tore M. Undeland and William P.Robbins, *Power Electronics: Converters, Applications and Design*, New Jersey, John Wiley and Sons, 2003.
3. M.H. Rashid, *Power Electronics: Circuits, Devices and Application*, New Delhi, Prentice Hall of India, 2004.
4. M D Singh and K B Khanchandani, *Power Electronics*, New Delhi, Tata McGraw-Hill, 2008.
5. B.W. Williams, *Power Electronics: Devices, Drivers, Applications and Passive Components*, New York, McGraw-Hill, 1992

1702PE103 ANALYSIS OF POWER CONVERTERS

L	T	P	C
3	0	0	3

Course Objectives:

1. To understand the classifications of power converters.
2. To analyze the power converters to determine its various performance parameters.
3. To apply PWM techniques for different power converters.

UNIT I SINGLE PHASE AC-DC CONVERTER **9 Hours**

Static Characteristics of power diode, SCR and GTO, half controlled and fully controlled converters with R-L, R-L-E loads and freewheeling diodes – continuous and discontinuous modes of operation - inverter operation –Sequence control of converters – performance parameters: harmonics, ripple, distortion, power factor – effect of source impedance and Overlap-reactive power and power balance in converter circuits

UNIT II THREE PHASE AC-DC CONVERTER **9 Hours**

Semi and fully controlled converter with R, R-L, R-L-E - loads and freewheeling diodes – inverter operation and its limit – performance parameters – effect of source impedance and over lap – 12 pulse converter.

UNIT III DC-DC CONVERTERS **9 Hours**

Principles of step-down and step-up converters – Analysis of buck, boost, buck-boost and Cuk converters – time ratio and current limit control – Full bridge converter – Resonant and quasi – resonant converters.

UNIT IV AC VOLTAGE CONTROLLERS **9 Hours**

Static Characteristics of TRIAC- Principle of phase control: single phase and three phase controllers – various configurations – analysis with R and R-L loads.

UNIT V CYCLOCONVERTERS **9 Hours**

Principle of operation – Single phase and Three-phase Dual converters - Single phase and three phase cyclo-converters – power factor Control – Introduction to matrix converters.

TOTAL: 45 HOURS

FURTHER READING:

Application of Random PWM techniques for Power Converters

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

CO1: List the classifications of power converters

CO2: Explain the different modes of operation of power converters like AC- DC, DC – AC & AC – AC converters (Single Phase & Three phase).

CO3: Explain the control of power converters with various PWM techniques like Single, Multi, Sine and SVPWM.

CO4: Analyze the performance parameters of power converters.

CO5: Explain the application of power converters.

REFERENCES:

1. Rashid M.H., “Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Third Edition, New Delhi, 2004.
2. Jai P.Agrawal, “Power Electronics Systems”, Pearson Education, Second Edition, 2002.
3. Bimal K.Bose “Modern Power Electronics and AC Drives”, Pearson Education, Second Edition, 2003.
4. Ned Mohan,T.MUndeland and W.P Robbin, “Power Electronics: converters, Application and design” John Wiley and sons.Wiley India edition, 2006.
5. Philip T. krein, “Elements of Power Electronics” Oxford University Press -1998.
6. P.C. Sen, “Modern Power Electronics”, Wheeler Publishing Co, First Edition, New Delhi,1998.
7. P.S.Bimbra, “Power Electronics”, Khanna Publishers, Eleventh Edition, 2003.

1702PE104	ANALYSIS OF INVERTERS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To understand the classifications of Inverters.
2. To analyze the Inverters to determine its various performance parameters.
3. To analyze ZVS and ZCS in a inverter.

UNIT I BASIC INVERTERS **9 Hours**

Basic series inverter – Modified series inverter- High frequency series inverter- Design of L and C – Parallel inverter- Design of parallel inverter.- Line commutated inverter – Concepts of PWM techniques.

UNIT II VOLTAGE SOURCE INVERTERS **9 Hours**

Principle of operation of half and full bridge inverters – Three phase inverters with 180 degree and 120 degree conduction mode with star and delta connected loads- Performance parameters – Voltage control of single phase and three phase inverters using various PWM techniques – Various harmonic elimination techniques.

UNIT III CURRENT SOURCE AND IMPEDANCE SOURCE INVERTERS **9 Hours**

Load commutated current source inverter- Single phase and three phase auto sequential current source inverter (ASCI) – Principle of operation of impedance source inverter- Shoot thro zero state – Comparison of current source inverter, Voltage source inverters and impedance source inverter

UNIT IV MULTILEVEL INVERTERS **9 Hours**

Multilevel concept – Diode clamped – Flying capacitor – Cascade type multilevel inverters – Hybrid multi level inverter- FFT analysis- Comparison of multilevel inverters - Applications of multilevel inverters.

UNIT V RESONANT INVERTERS **9 Hours**

Concept of Zero Voltage Switching and Zero Current Switching - Series and parallel resonant inverters - Voltage control of resonant inverters – Class E resonant inverter – Resonant DC Link inverters.

TOTAL: 45 HOURS

FURTHER READING:

Applications of Inverters in Renewable Energy system

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

CO1: Explain the performance of series and parallel inverter with PWM techniques
CO2: Explain the working of voltage source inverters and also its control with PWM techniques.
CO3: Explain the working of current source inverter and impedance source inverter.
CO4: Explain the classifications, working and applications of multilevel inverter.
CO5: Explain the concept of ZVS, ZCS and resonant inverters.

REFERENCES:

1. P.S. Bimbra, *Power Electronics*, New Delhi, Khanna Publishers, 2006.
2. M.H. Rashid, *Hand Book of Power Electronics: Circuits, Devices and Application*, New Delhi, Prentice Hall of India, 2007.
3. Ned Mohan, Tore M. Undeland and William P.Robbins, *Power Electronics: Converters, Applications and Design*, 3rd Edition, John Wiley and Sons, 2002.
4. Jai P. Agrawal, *Power Electronics Systems*, 2nd Edition, Pearson Education, 2002.
5. Bimal K. Bose, *Modern Power Electronics and Motor Drive- Advances and Trends*, 2nd Edition, Pearson Education, 2006.

1702PE105 MODELING AND ANALYSIS OF ELECTRICAL MACHINES

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. To understand the classifications of power converters.
2. To analyze the power converters to determine its various performance parameters.
3. To apply PWM techniques for different power converters.

UNIT I CONCEPTS OF ROTATING MACHINES **9 Hours**

Calculation of air gap mmf of a single turn full pitch distributed armature windings - Per phase full pitched and short pitched armature coils (AC machines) - Calculation of air gap mmf of a DC machine - Introduction to direct axis and quadrature axis theory in salient pole machines - Calculation of air gap inductances of a synchronous machine.

UNIT II INDUCTION MACHINE MODELING **9 Hours**

Static and rotating References: frames, transformation relationships - Stationary circuit variables transformed to the arbitrary Reference frame treating R, L, C elements separately - Application of Reference frame theory to three phase symmetrical induction machine - Direct and quadrature axis model in arbitrarily rotating Reference frame - Voltage and torque equations.

UNIT III SYNCHRONOUS MACHINE MODELING **9 Hours**

Application of reference frame theory to three phase synchronous machine-dynamic model analysis-Park‟s equation - Voltage and torque equations - Deviation of steady state phasor relationship from dynamic model - Generalized theory of rotating electrical machine and Kron‟s primitive machine.

UNIT IV SYNCHRONOUS MACHINE MODELING **9 Hours**

Synchronous machine dynamic equivalent circuit parameters - Standard and derived machine time constants - Frequency response test, Analysis and dynamic modeling of two phase asymmetrical induction machine and single phase induction machine.

UNIT V SPECIAL MACHINES **9 Hours**

Permanent magnet synchronous machine, Surface permanent magnet (square and sinusoidal back emf type) and interior permanent magnet machines - Construction and operating principle - Dynamic modeling and self controlled operation – Dynamic analysis of Switched Reluctance Motors.

TOTAL: 45 HOURS

FURTHER READING:

Dynamic Modeling of Linear motors

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

CO1: Brief the fundamental concepts of rotating machines.
CO2: Determine the air gap mmf of DC and AC machines.
CO3: Explain the application of reference theory Induction Machine, Synchronous Machine and Special Machines.
CO4: Analyze the dynamic modeling of Induction Machine, Synchronous Machine and Special Machines.
CO5: Analyze the electrical machine equivalent parameters.

REFERENCES:

1. Charles Kingsley Jr., A.E. Fitzgerald and Stephen D.Umans, *Electric Machinery*, New York, McGraw-Hill Higher Education, 2010.
2. Paul C. Krause, Oleg Wasynczuk and Scott D. Sudhoff, *Analysis of Electric Machinery and Drive Systems*,New Jersey, Wiley Student Edition, 2013.
3. R. Krishnan, *Electric Motor & Drives: Modeling, Analysis and Control*, New Delhi, Prentice Hall of India,2001.
4. T.J.E. Miller and J R Hendershot Jr., *Design of Brushless Permanent Magnet Motors*, USA, Oxford University Press, 1994.
5. T.J.E. Miller, *Reluctance Motor and their Controls*, USA, Oxford University Press, 1993

1704PE106 POWER ELECTRONIC CIRCUITS LABORATORY

L	T	P	C
0	0	2	1

COURSE OBJECTIVES:

1. To obtain the switching characteristic of different types of power semi-conductor devices.
2. To determine the operation, characteristics and performance parameters of controlled rectifiers.
3. To apply switching techniques and basic topologies of DC-DC switching regulators.

LIST OF EXPERIMENTS:

1. Single phase half controlled converter with RL and RLE loads.
2. Single phase full controlled converter with RL and RLE loads.
3. Single phase series inverter.
4. Single phase parallel inverter.
5. Single phase cycloconverter.
6. Three phase fully controlled converter with RL and RLE loads.
7. MOSFET based step up and step down chopper.
8. Single phase PWM inverter.
9. AC voltage controller.
10. Resonant converter.

TOTAL: 45 HOURS

ADDITIONAL EXPERIMENTS:

Fabricate the Boost converter for Photovoltaic applications

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

CO1: Draw the characteristics of Power electronics devices.
CO2: Determine the various parameters of single phase and three phase rectifier.
CO3: Demonstrate the response of chopper for a dc load
CO4: Diagnose the various causes of harmonics
CO5: Design a PWM converter and an ac voltage regulator

REFERENCES:

1. Ned Mohan,T.M. Undeland and W.P Robbin, “Power Electronics: converters, Application and design” John Wiley and sons. Wiley India edition, 2006.
2. Rashid M.H., “Power Electronics Circuits, Devices and Applications ", Prentice Hal India, New Delhi, 1995

1704PE107 POWER ELECTRONICS SIMULATION LABORATORY

L	T	P	C
0	0	2	1

COURSE OBJECTIVES:

1. To determine the performance curves for various power electronic circuits.
2. To determine the performance parameters of various power electronic circuits
3. To determine the solutions for differential equations.

LIST OF EXPERIMENTS:

1. Simulation of single phase half wave controlled converter fed RLE load2.
2. Simulation of single phase fully controlled converter fed RLE load.
3. Simulation of three phase half controlled converter fed RL load.
4. Simulation of three phase fully controlled converter fed RL load.
5. Simulation of dynamics of armature plunger / relay contactor arrangement.
6. Simulation of dynamics of doubly excited system.
7. Simulation of single phase VSI fed RL/RC load.
8. Simulation of i) LC tank circuit resonance, ii) Basic / modified series inverter, iii) Series loaded series resonant inverter
9. Simulation of single phase current source inverter fed induction heating load.
10. Simulation of multi level inverter topologies.
11. Numerical solution of ordinary differential equations.
12. Numerical solution of partial differential equations

TOTAL: 45 HOURS

ADDITIONAL EXPERIMENTS:

Simulation of a Power Converter with SVPWM technique.

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

CO1: Simulate the different power converters with RL Load to determine the performance curves.
CO2: Simulate the different power converters with RLE Load to determine the performance curves.
CO3: Simulate the different power converters with RL Load to determine the performance parameters.
CO4: Simulate the different power converters with RLE Load to determine the performance parameters.
CO5: Simulate the differential equations to find out the numerical solution.

REFERENCES:

1. Ned Mohan,T.M. Undeland and W.P Robbin, “Power Electronics: converters, Application and design” John Wiley and sons. Wiley India edition, 2006.
2. Rashid M.H., “Power Electronics Circuits, Devices and Applications ", Prentice Hal India, New Delhi, 1995.

1704PE108 **COMMUNICATION SKILLS LAB I** (Common to all M.E Progarmmes)

L	T	P	C
0	0	2	1

COURSE OBJECTIVES:

1. To acquire skills for using English in workplace effectively.
2. To communicate for essential business needs.
3. To prepare students for taking BEC Vantage level examination which is an International Benchmark for English language proficiency of Cambridge English Language Assessment

LIST OF EXPERIMENTS:

1. GRAMMAR AND VOCABULARY

Forming asking complex questions – expressing purpose and function –modal verbs – impersonal passive voice– Reported speech – cause and effect – relative pronouns – expressions followed by – *ing* forms– acronyms – marketing terms / vocabulary – financial terms – collocations – discourse markers

2. LISTENING

Purposes of listening – features of listening texts – potential barriers to listening – specific listening skills – strategies to use when listening– distinguishing relevant from irrelevant information – gap filling exercise – multiple-choice options – note completion – matching and multiple choice questions – listening for specific information, gist, topic, context and function.

3. SPEAKING

Word and sentence stress – clear individual sounds – turn taking – initiating and responding **-** intonation patterns – pronunciation – mother tongue intrusion– conversation practice – turn-taking and sustaining the interaction by initiating and responding appropriately- Public Speech – Lectures.

4. READING

Purposes of reading – potential barriers to reading – paraphrasing – identifying facts and ideas – skimming and scanning for information – matching statements with texts– spotting reference words – understanding text structure – understanding the ideas in a text – distinguishing between the correct answer and the distracter – understanding cohesion in a text – deciphering contextual meaning of words and phrases – cloze – proof reading - transcoding.

5. WRITING

Paragraphing a text – using appropriate connectives – editing practice –Longer Documents: writing a proposal & Reports, Agenda – Minutes – Circular

TOTAL: 30 HOURS

ADDITIONAL EXPERIMENTS:

1. Body Language: Kinesics, Proxemics, Para linguistic, Nuances of Speech Delivery
2. Personality Development: Building self esteem
3. Team work

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

CO1: To enable students to get International recognition for work and study.

CO2: To use English confidently in the International business environments.

CO3: To be able to take part in business discussion, read company literature, write formal and informal business correspondences and listen and understand business conversations

REFERENCES:

1. Guy Brook-Hart, “BEC VANTAGE: BUSINESS BENCHMARK Upper-Intermediate – Student’s Book”, 1st Edition, Cambridge University Press, New Delhi, 2006.
2. Cambridge Examinations Publishing, “Cambridge BEC VANTAGE – Self-study Edition”, Cambridge University Press, UK, 2005.
3. Swets, Paul. W. 1983. The Art of Talking So That People Will Listen: Getting
4. The Process of Writing: Planning and Research, Writing, Drafting and Revising

1701PE201	RESEARCH METHODOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To understand the fundamentals of Research Methodology.
2. To analyze the various sampling methods.
3. To perform different test in research methodology.

UNIT I INTRODUCTION 10 Hours

Research methodology – definition, mathematical tools for analysis, Types of research, exploratory research, conclusive research, modeling research, algorithmic research, Research process- steps. Data collection methods- Primary data – observation method, personal interview, telephonic interview, mail survey, questionnaire design. Secondary data- internal sources of data, external sources of data.

UNIT II SCALES AND SAMPLING 11 Hours

Scales – measurement, Types of scale – Thurstone's Case V scale model, Osgood's Semantic Differential scale, Likert scale, Q- sort scale. Sampling methods- Probability sampling methods – simple random sampling with replacement, simple random sampling without replacement, stratified sampling, cluster sampling. Non-probability sampling method – convenience sampling, judgment sampling, quota sampling.

UNIT III HYPOTHESIS TESTING 7 Hours

Hypothesis testing – Testing of hypotheses concerning means (one mean and difference between two means - one tailed and two tailed tests), concerning variance – one tailed Chi-square test.

UNIT IV MULTIVARIATE STATISTICAL TECHNIQUES 8 Hours

Data Analysis – Factor Analysis – Cluster Analysis – Discriminant Analysis – Multiple Regression and correlation – Canonical Correlation – Application of statistical (SPSS) Software Package in Research.

UNIT V RESEARCH REPORT 9 Hours

Purpose of the written report - Concept of Audience – Basics of written reports. Integral Parts of Report – Title of a Report, Table of Contents, Abstract, Synopsis, Introduction, Body of a Report – Experimental, Results and Discussion – Recommendations and Implementation Section – Conclusions and Scope for future work.

TOTAL: 45 HOURS

FURTHER READING:

Report writing for Assignments – A Case Study

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

CO1: Explain the fundamentals of research methodology.
CO2: Elucidate the classification of scales and sampling methods.
CO3: Apply the hypothesis testing in research methodology.
CO4: Explain the methods of Data Analysis in research.
CO5: Discuss about report writing.

REFERENCES:

9. Panneerselvam, R., Research Methodology, Prentice-Hall of India, New Delhi, 2004.
10. Kothari, C.R., Research Methodology –Methods and Techniques, New Age International.

1702PE202 **SOLID STATE DC DRIVES**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. To understand the fundamentals of DC Drives.
2. To analyze the various control techniques for DC drives.
3. To determine the performance parameters of DC drives.

UNIT I DC MOTORS FUNDAMENTALS AND MECHANICAL SYSTEMS **9 Hours**

DC motor- Types, induced emf, speed-torque relations; Speed control – Armature and field speed control; Ward Leonard control – Constant torque and constant horse power operation -Introduction to high speed drives and modern drives. Characteristics of mechanical system – dynamic equations, components of torque, types of load; Requirements of drives characteristics - stability of drives – multi-quadrant operation; Drive elements, types of motor duty and selection of motor rating.

UNIT II CONVERTER CONTROL **9 Hours**

Principle of phase control – Fundamental relations; Analysis of series and separately excited DC motor with single-phase and three-phase converters – waveforms, performance parameters, performance characteristics. Continuous and discontinuous armature current operations; Current ripple and its effect on performance; Operation with freewheeling diode; Implementation of braking schemes; Drive employing dual converter.

UNIT III CHOPPER CONTROL **9 Hours**

Introduction to time ratio control and frequency modulation; Class A, B, C, D and E chopper controlled DC motor – performance analysis, multi-quadrant control - Chopper based implementation of braking schemes; Multi-phase chopper; Related problems.

UNIT IV CLOSED LOOP CONTROL **9 Hours**

Modeling of drive elements – Equivalent circuit, transfer function of self, separately excited DC motors; Linear Transfer function model of power converters; Sensing and feeds back elements - Closed loop speed control – current and speed loops, P, PI and PID controllers – response comparison. Simulation of converter and chopper fed d.c drive.

UNIT V DIGITAL CONTROL OF DC DRIVE **9 Hours**

Phase Locked Loop and micro-computer control of DC drives – Program flow chart for constant horse power and load disturbed operations; Speed detection and current sensing circuits.

TOTAL: 45 HOURS

FURTHER READING:

Application of DC Drives in Shopping malls – A case study.

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

CO1: Explain the fundamentals of DC Drives.
CO2: Explain the performance of converter and chopper controlled DC Drives in different quadrants.
CO3: Calculate the performance parameters of converter and chopper controlled DC drives..
CO4: Apply the closed loop and Digital control scheme for DC drives.
CO5: List the applications of DC drives.

REFERENCES:

1. Gopal K Dubey, "Power Semiconductor controlled Drives", Prentice Hall Inc., New Yersy, 1989.
2. R.Krishnan, "Electric Motor Drives – Modeling, Analysis and Control", Prentice-Hall of India Pvt. Ltd., New Delhi, 2010.
3. GobalK.Dubey, "Fundamentals of Electrical Drives", Narosal Publishing House, New Delhi, Second Edition ,2009
4. Vedam Subramanyam, "Electric Drives – Concepts and Applications", Tata McGraw-Hill publishing company Ltd., New Delhi, 2002.
5. P.C Sen "Thyristor DC Drives", John wiely and sons, New York, 1981.

1702PE203 **SOLID STATE AC DRIVES**

L	T	P	C
3	0	0	3

Course Objectives:

1. To understand the fundamentals of AC Drives.
2. To analyze the various control techniques for AC drives.
3. To determine the performance parameters of AC drives.

UNIT I INTRODUCTION TO INDUCTION MOTORS **9 Hours**

Steady state performance equations – Rotating magnetic field – torque production, Equivalent circuit– Variable voltage, constant frequency operation –Variable frequency operation, constant Volt/Hz operation. Drive operating regions, variable stator current operation, different braking methods.

UNIT II VSI AND CSI FED INDUCTION MOTOR CONTROL **9 Hours**

AC voltage controller circuit – six step inverter voltage control-closed loop variable frequency PWM inverter with dynamic braking-CSI fed IM variable frequency drives comparison

UNIT III ROTOR CONTROLLED INDUCTION MOTOR DRIVES **9 Hours**

Static rotor resistance control - injection of voltage in the rotor circuit – static scherbius drives - power factor considerations – modified Kramer drives

UNIT IV FIELD ORIENTED CONTROL **9 Hours**

Field oriented control of induction machines – Theory – DC drive analogy – Direct and Indirect methods – Flux vector estimation - Direct torque control of Induction Machines – Torque expression with stator and rotor fluxes, DTC control strategy.

UNIT V SYNCHRONOUS MOTOR DRIVES **9 Hours**

Wound field cylindrical rotor motor – Equivalent circuits – performance equations of operation from a voltage source – Power factor control and V curves – starting and braking, self control – Load commutated Synchronous motor drives - Brush and Brushless excitation .

TOTAL: 45 HOURS

FURTHER READING:

Application of AC drives in Spinning Mills – A case Study.

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

CO1: Explain the fundamentals of AC Drives.
CO2: Apply the stator and rotor controlled techniques in AC Drives.
CO3: Explain the performance of AC drives with Field Oriented Control and Direct Torque Control.
CO4: Explain the performance and classification of synchronous motor drive.
CO5: Determine the performance parameters of AC drives with various control techniques.

REFERENCES:

1. Bimal K Bose, "Modern Power Electronics and AC Drives", Pearson Education Asia 2002.
2. Vedam Subramanyam, "Electric Drives – Concepts and Applications", Tata McGraw Hill, 1994.
3. Gopal K Dubey, "Power Semiconductor controlled Drives", Prentice Hall Inc., New Yersy, 1989.
4. R.Krishnan, "Electric Motor Drives – Modeling, Analysis and Control", Prentice-Hall of India Pvt. Ltd., New Delhi, 2003
5. W.Leonhard, "Control of Electrical Drives", Narosa Publishing House, 1992.
6. Murphy J.M.D and Turnbull, "Thyristor Control of AC Motors", Pergamon Press, Oxford, 1988.

1702PE204 **POWER QUALITY ISSUES AND SOLUTIONS**

L	T	P	C
3	**0**	**0**	**3**

COURSE OBJECTIVES:

1. To understand the short and long variations in power system.
2. To analyze the short and long interruptions in drives.
3. To understand the harmonics and mitigating of harmonics.

UNIT I **INTRODUCTION** **9 Hours**

Definition of power quality - Power quality, Voltage quality - Power quality issues: Short duration voltage variations, Long duration voltage variations, Transients, Waveform distortion, Voltage imbalance, Voltage fluctuation, Power frequency variations - Sources and Effects of power quality problems - Power quality terms - Power quality and Electro Magnetic Compatibility (EMC) Standards. CBEMA & ITI curves.

UNIT II **SHORT INTERRUPTIONS AND LONG INTERRUPTIONS** **9 Hours**

Short Interruptions - Introduction - Origin of short interruptions: Voltage magnitude events due to reclosing, Voltage during the interruption- Monitoring of short interruptions - End user issues: Influence on Induction motors, Synchronous motors, Adjustable speed drives. Long Interruptions Definition - Terminology: Failure, Outage, Interruption - Origin of interruptions - Causes of long interruptions - Principles of regulating the voltage - Voltage regulating devices, Applications: Utility side, End-User side.

UNIT III **VOLTAGE SAGS AND TRANSIENTS** **9 Hours**

Voltage Sag-Introduction - Definition - Characterization: Magnitude, Duration - Causes of Voltage Sag - Three Phase Unbalance - Phase angle jumps - Load influence on voltage sags - Overview of mitigation methods. Transients Definition - Principles of over voltage protection - Types and causes of transients - Devices for over voltage protection - Utility capacitor switching transients - Utility lightning protection – Waveform Distortion.

UNIT IV **HARMONICS** **9 Hours**

Introduction - Definition and terms in Harmonics, Harmonics indices, Inter harmonics, Notching - Voltage Vs Current distortion - Harmonics Vs Transients - Sources and effects of harmonic distortion - System response characteristics - Principles of controlling harmonics - Standards and limitation - Mitigation and control techniques.

UNIT V **POWER QUALITY SOLUTIONS** **9 Hours**

Introduction - Power quality monitoring: Need for power quality monitoring, Evolution of power quality monitoring, Deregulation effect on power quality monitoring - Brief introduction to power quality - measurement equipments and power conditioning equipments - Planning, Conducting and Analyzing power quality survey.

TOTAL: 45 HOURS

FURTHER READING:

Analysis of Over Voltage due to Lightning in India – A case Study.

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

- CO1: Describe the power quality problem with sources and its effects
- CO2: Explain the short and long interruptions in Induction motors, Synchronous motors and adjustable drives.
- CO3: Explain the voltage sag and over voltage- causes, mitigation techniques and principles of protection circuits.
- CO4: Explain the sources and effects of harmonics with mitigation techniques of harmonics.
- CO5: Explain the monitoring, conditioning of power quality and also equipment's for power quality improvements.

REFERENCES:

1. Barry W. Kennedy, Power Quality Primer, New York, McGraw-Hill, 2000.
2. C. Sankaran, Power Quality, Washington, CRC Press, 2001.
3. Math H.J. Bollen, Understanding Power Quality Problems: Voltage Sags and Interruptions, New York, IEEE Press, 1999.
4. J. Arriliaga, N.R. Watson and S. Chen, Power System Quality Assessment, England, John Wiley, & Sons, 2000.
5. Dugan, Mark F. Mc Granaghan and H. Wayne Beaty, Electrical Power Systems Quality, NewYork, McGraw-Hill, 2002.

1702PE205 **MODELLING AND DESIGN OF SMPS**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. To understand the steady state analysis for converters.
2. To analyze the state space model of converters.
3. To design the controllers and machines.

UNIT I STEADY-STATE CONVERTER ANALYSIS **9 Hours**

Buck, Boost, Buck- Boost and Cuk converters: Principles of operation – Continuous conduction mode – Concepts of volt-sec balance and charge balance – Analysis and design based on steady-state relationships – Introduction to discontinuous conduction more – Isolation topologies.

UNIT II CONVERTER DYNAMICS **9 Hours**

AC equivalent circuit analysis – State space averaging – Circuit averaging – Averaged switch modeling – Transfer function model for Buck, Boost, Buck-Boost and Cuk converters – Input filters.

UNIT III CONTROLLER DESIGN **9 Hours**

Review of P, PI, and PID control concepts – gain margin and phase margin – Bode plot based analysis – Design of controller for Buck, Boost, Buck-Boost and Cuk converters.

UNIT IV DESIGN OF MAGNETICS **9 Hours**

Basic magnetic theory revision – Inductor design – Design of mutual inductance – Design of transformer for isolated topologies – Ferrite core table and selection of area product – wire table – selection of wire gauge.

UNIT V RESONANT CONVERTERS **9 Hours**

Introduction- classification- basic concepts- Resonant switch- Load Resonant converters- ZVS, Clamped voltage topologies- Series and parallel Resonant converters- Voltage control.

TOTAL: 45 HOURS

FURTHER READING:

Applications of SMPS in super computers.

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

CO1: Explain the steady state analysis of converters in continuous and discontinuous conduction modes.
CO2: Perform the state space analysis for converter circuits.
CO3: Explain the conventional controllers design for Buck, Boost and Buck Boost converter.
CO4: Design inductance and transformer for SMPS.
CO5: Explain various types of resonant converters.

REFERENCES:

1. Robert W. Erickson &Dragon Maksimovic" Fundamentals of Power Electronics" Second Edition, 2001 Springer science and Business media
2. John G.Kassakian, Martin F. Schlecht, George C. Verghese, "Principles of Power Electronics" Pearson, India, New Delhi, 2010.
3. Simon Ang and Alejandra Oliva, "Power Switching Converter" Yesdee publishers, New Delhi, 2nd edition (first Indian Reprint), 2010.
4. Philip T Krein, " Elements of Power Electronics", Oxford University Press

1704PE206 **ELECTRICAL DRIVES LAB**

L	T	P	C
0	0	2	1

COURSE OBJECTIVES:

1. To analyze the performance of drives when it is controlled by a converter.
2. To analyze the control of special machines.
3. To understand the design of SMPS and UPS.

LIST OF EXPERIMENTS:

1. Speed control of Converter fed DC motor.
2. Speed control of Chopper fed DC motor.
3. V/f control of three-phase induction motor.
4. Micro controller based speed control of Stepper motor.
5. Speed control of BLDC motor.
6. DSP based speed control of SRM motor.
7. Design of switched mode power supplies.
8. Design of UPS.
9. Simulation of Four quadrant operation of three-phase induction motor.
10. Voltage Regulation of three-phase Synchronous Generator.
11. Study of power quality analyzer.
12. Study of driver circuits and generation of PWM signals for three phase inverters.

TOTAL: 45 HOURS

ADDITIONAL EXPERIMENTS:

Cyclo Converter fed Induction Motor Drive.

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

CO1: Determine the performance of converter and chopper controlled DC Drives.
CO2: Determine the performance of V/f controlled induction motor drive.
CO3: Determine the performance of special machines.
CO4: Understand the PWM signals generation and application to converters.
CO5: Analyze the design of SMPS and UPS.

REFERENCES:

3. Ned Mohan,T.M. Undeland and W.P Robbin, “Power Electronics: converters, Application and design” John Wiley and sons. Wiley India edition, 2006.
4. Rashid M.H., “Power Electronics Circuits, Devices and Applications ", Prentice Hal India, New Delhi, 1995

1704PE208 **COMMUNICATION SKILLS LAB II**
(Common to all M.E Progarmmes)

L	T	P	C
0	0	2	1

COURSE OBJECTIVES:

1. To acquire skills for using English in business environment.
2. To communicate appropriately in business contexts.
3. To prepare students for taking BEC Vantage level examination conducted by the Cambridge English Language Assessment (CELA).

SPEAKING

Non-verbal communication – agreeing / disagreeing, reaching decisions, giving and supporting opinions – making mini presentations – extending on conservations – collaborative task – tongue twisters.

WRITING

Business letters – fax – Shorter Documents: e-mail - memo – message - note – report writing – formal / informal styles.

TOTAL: 15 HOURS

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

CO1: To enable students to acquire business terms for communication.

CO2: To use English confidently in the business contexts.

CO3: To be able to take part in business discussion and write formal and informal business correspondences.

REFERENCES:

5. Guy Brook-Hart, "BEC VANTAGE: BUSINESS BENCHMARK Upper-Intermediate – Student's Book", 1st Edition, Cambridge University Press, New Delhi, 2006.
6. Cambridge Examinations Publishing, "Cambridge BEC VANTAGE – Self-study Edition", Cambridge University Press, UK, 2005.
7. Swets, Paul. W. 1983. The Art of Talking So That People Will Listen: Getting
8. The Process of Writing: Planning and Research, Writing, Drafting and Revising

1703PE002 POWER CONVERTERS FOR SOLAR AND WIND ENERGY CONVERSION SYSTEM

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. To understand the energy scenario in the world and in nation.
2. To analyze the power generation from solar and wind.
3. To analyze the issues of grid integration of wind and solar energy conversion system.

UNIT I INTRODUCTION **9 Hours**

Trends in energy consumption - World energy scenario - Energy source and their availability – Conventional and renewable source - Need to develop new energy technologies- MNRE Rules and Regulations-TEDA-Wind and solar survey in India and World.

UNIT II PHOTOVOLTAIC ENERGY CONVERSION **9 Hours**

Solar radiation and measurements - Solar cells – Panels and their characteristics – Influence of insulation and temperature – PV arrays –Maximum power point tracking – Applications – Water pumping – Street lighting – DC-DC converters for solar PV systems.

UNIT III WIND ENERGY SYSTEMS **9 Hours**

Basic principle of Wind Energy Conversion System – Nature of Wind –Components of Wind Energy Conversion System –Generators for WECS- Classifications of WECS – Self excited induction generator - synchronous generator - Power conditioning schemes.

UNIT IV GRID CONNECTED WECS AND SECS **9 Hours**

Grid connectors – Wind farm and its accessories – Grid related problems – Generator control –Performance improvements - Different schemes – Matrix converters -Line commutated inverters-Multilevel inverters-Power converters for Grid connected WECS-Grid connected solar energy converter systems.

UNIT V DISTRIBUTED POWER GENERATION SYSTEMS **9 Hours**

Solar – PV – Hybrid Systems – Selection of power conversion ratio – Optimization of System components – Storage - Reliability evolution – Types of Cogeneration processes – Power converters for distributed power systems.

TOTAL: 45 HOURS

FURTHER READING:

Power controllers in Combined power generation system with steam and diesel

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

CO1: Explain the energy sources, consumption and technologies available in the world and in India.
CO2: Elucidate the power converters used in solar and wind energy conversion system
CO3: Illustrate the power controllers used for grid integration of WECS and SECS.
CO4: Discuss about the various electrical machines involved wind energy conversion system.
CO5: Explain the concepts of distributed generation.

REFERENCES:

1. S. Rao and Parulekar, Energy Technology – Non Conventional, Renewable and Conventional, New Delhi, Khanna Publishers, 1999.
2. Mukund R. Patel, Wind and Solar Power System, New York, CRC Press LLC, 1999.
3. Ned Mohan, Tore M. Undeland and William P.Robbins, Power Electronics: Converters, Applications and Design, New Jersey, John Wiley and Sons, 2003.
4. M.H. Rashid, Power Electronics Circuits, Devices and Applications, New Delhi, Prentice Hall of India, 2004.
5. Anbukumar kavitha and Govindarajan Uma, Experimental Verification of Hopf Bifurcation in DC-DC Luo Converter, Vol.23, No.6, IEEE Transaction on Power Electronics, 2008, pp 2878 2883.
6. A. Mustafa, Al-Saffar, Esam H.Ismail, Ahmad J.Sabzali and Abbas A.Fardoun, An Improved Topology of SEPIC Converter with Reduced Output Voltage Ripple, Vol.23, No.5, IEEE Transactions on Power Electronics, September 2008, pp 2377-2386.

1703PE012 SOLAR AND ENERGY STORAGE SYSTEM

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. To understand the fundamentals of semiconductors and solar cells.
2. To analyze the power generation from solar energy.
3. To analyze the energy storage system for energy generated through solar.

UNIT I INTRODUCTION **9 Hours**

Characteristics of sunlight – semiconductors and P-N junctions –behavior of solar cells – cell properties – PV cell interconnection

UNIT II STAND ALONE PV SYSTEM **9 Hours**

Solar modules – storage systems – power conditioning and regulation - protection – stand alone PV systems design – sizing

UNIT III GRID CONNECTED PV SYSTEMS **9 Hours**

PV systems in buildings – design issues for central power stations – safety – Economic aspect – Efficiency and performance - International PV programs

UNIT IV ENERGY STORAGE SYSTEMS **9 Hours**

Impact of intermittent generation – Battery energy storage – solar thermal energy storage – pumped hydroelectric energy storage

UNIT V APPLICATIONS **9 Hours**

Water pumping – battery chargers – solar car – direct-drive applications –Space – Telecommunications.

TOTAL: 45 HOURS

FURTHER READING:

Applications of solar energy system in Indian satellites – A Case Study.

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

CO1: Explain the fundamentals of solar energy system, semiconductors and solar cells.
CO2: Explain the energy generation from stand alone solar energy conversion system.
CO3: Explain the energy generation from grid integration solar energy conversion system.
CO4: Explain the energy storage system for solar energy conversion system.
CO5: Explain the applications of solar energy conversion system.

REFERENCES:

1. Eduardo Lorenzo G. Araujo, Solar electricity engineering of photovoltaic systems,Progensa,1994.
2. Stuart R.Wenham, Martin A.Green, Muriel E. Watt and Richard Corkish, Applied Photovoltaics, 2007,Earth scan, UK.
3. Frank S. Barnes & Jonah G. Levine, Large Energy storage Systems Handbook , CRC Press, 2011.
4. Solar & Wind energy Technologies – McNeils, Frenkel, Desai, Wiley Eastern, 1990
5. Solar Energy – S.P. Sukhatme, Tata McGraw Hill,1987.

1703PE001 RECENT TRENDS IN POWER CONVERSION TECHNOLOGY **LTPC**
3 0 0 3

COURSE OBJECTIVE

- To analyze the recent DC – DC converters.
- To analyze the recent AC – AC converters.
- To analyze the PWM techniques, Control Techniques, Harmonics Mitigating techniques and applications.

UNIT 1 SWITCHING TECHNIQUES **8 Hours**
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 **10 Hours**
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 **11 Hours**
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 **8 Hours**
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 **8 Hours**
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.

Total :45 Hours

FURTHER READING:

Applications of Matrix converter in Special Machines

COURSE OUTCOME

On completion of the course the students will be able to

1. Explain the SVPWM and SVM techniques.
2. Explain the Luo converter and its applications in photovoltaic systems.
3. Explain the Multi level and hybrid multi level concepts and its application in UPS & Drives.
4. Explain the various recent matrix converters and its applications.
5. Explain the harmonics mitigating techniques.

REFERENCES:

1. Ned Mohan, Undeland and Robbin, *Power Electronics: Converters, Application and Design*, NewYork, John Wiley and Sons Inc., 2002.

2. 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.
3. R. Krishnan, *Electric Motor Drives – Modeling, Analysis and Control*, New Delhi, Prentice Hall of India, 2003.
4. 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.
5. S. Masoud Barakati, *Applications of Matrix Converters for Wind Turbine Systems*, Germany, VDM Verlag Publishers, 2008.

1703PE008 OPTIMIZATION TECHNIQUES **LTPC 3 0 0 3**

COURSE OBJECTIVE

1. To introduce the different optimization problems and techniques
2. To study the fundamentals of the linear and non-linear programming problem.
3. To understand the concept of dynamic programming and genetic algorithm technique

UNIT I INTRODUCTION TO OPTIMIZATION 7 Hours

Statement of Optimization problems - Classical optimization techniques - Single variable and multi variable optimization - Method of direct substitution constraint variation - Lagrange multipliers multivariable optimization with equality constraints - Kuhn Tucker conditions.

UNIT II LINEAR PROGRAMMING 6 Hours

Linear programming definition - Pivotal reduction of general system of equations - Simplex algorithms - Two phases of the simplex method - Revised simplex method - Duality in linear programming.

UNIT III NONLINEAR PROGRAMMING (ONE DIMENSIONAL) 5 Hours

Unimodal function – Elimination methods - Unrestricted and exhaustive search, Dichotomous search, Fibonacci method - Interpolation methods - Direct root method.

UNIT IV NONLINEAR PROGRAMMING 15 Hours

Unconstrained Optimization -Direct search methods - Univariate method, Pattern search methods - Rosenbrock's method – The simplex method - Descent method - Conjucate gradient method - Quasi NewtonMethods

Constrained Optimization **-** Direct methods - The Complex method - Cutting plane method - Methods of feasible directions and determination of step length - Termination criteria, determination of step length .

UNIT V DYNAMIC PROGRAMMING AND HEURISTIC TECHNIQUES FOR OPTIMIZATION 12 Hours

Multistage decision process - Computational procedure - Final value problem to initial value problem -Continuous dynamic programming - Discrete dynamic programming. Heuristic Techniques For Optimization - Neural Networks - Genetic algorithm – Adaptive genetic algorithm – particle swarm optimization - Ant Colony Optimization - Typical applications.

Total : 45 Hours

FURTHER READING:

Applications of AI techniques in wave form estimation for a Power Electronic Circuit

COURSE OUTCOME

On completion of the course the students will be able to

1. Explain different classifications of optimization problems and techniques.
2. Understand the linear programming concepts
3. Understand the application of non- linear programming in optimization techniques
4. Understand the fundamental concepts of dynamic programming
5. Explain about Genetic algorithm and its application to optimization in power system.

REFERENCES:

1. Nash S G and Ariela Sofer, "Linear and Nonlinear Programming", McGraw Hill Book Com Inc, New York, 1996.
2. David E Goldberg, "Genetic Algorithms in Search, Optimization and Machine learning", Addison Wesley Publishing Company, 1999.
3. Rao S S., "Optimization Theory and Applications", Wiley Eastern Limited, New Delhi, 2003.
4. Lawrence Hasdorff," Gradient Optimization and Non-Linear control", John Wiley & sons Inc, New York, 1976.
5. Dorigo M and Stutzle, T., "Ant Colony Optimization", Prentice Hall of India, 2004.

AFFILIATED INSTITUTIONS ANNA UNIVERSITY, CHENNAI

REGULATIONS – 2013

PX7301 POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS LT P C
3 0 0 3

UNIT I INTRODUCTION 9

Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (cost-GHG Emission) - Qualitative study of different renewable energy resources ocean, Biomass, Hydrogen energy systems : operating principles and characteristics of: Solar PV, Fuel cells, wind electrical systems-control strategy, operating area.

UNIT II ELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION 9

Review of reference theory fundamentals-principle of operation and analysis: IG, PMSG, SCIGand DFIG.

UNIT III POWER CONVERTERS 9

Solar: Block diagram of solar photo voltaic system : line commutated converters (inversion- mode) - Boost and buck-boost converters- selection Of inverter, battery sizing, array sizing.

Wind: three phase AC voltage controllers- AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, Grid Interactive Inverters-matrix converters.

UNIT IV ANALYSIS OF WIND AND PV SYSTEMS 9

Stand alone operation of fixed and variable speed wind energy conversion systems and solar system-Grid connection Issues -Grid integrated PMSG and SCIG Based WECS-Grid Integrated solar system.

UNIT V HYBRID RENEWABLE ENERGY SYSTEMS 9

Need for Hybrid Systems- Range and type of Hybrid systems- Case studies of Wind-PV- Maximum Power Point Tracking (MPPT).

TOTAL : 45 PERIODS

REFERENCES:

1. S.N.Bhadra, D. Kastha, & S. Banerjee “Wind Electricaal Systems”, Oxford University Press,2009
2. Rashid .M. H “power electronics Hand book”, Academic press, 2001.
3. Rai. G.D, “Non conventional energy sources”, Khanna publishes, 1993.
4. Rai. G.D,” Solar energy utilization”, Khanna publishes, 1993.
5. Gray, L. Johnson, “Wind energy system”, prentice hall linc, 1995.
6. Non-conventional Energy sources B.H.Khan Tata McGraw-hill Publishing Company,New Delhi.

PX7311 **PROJECT WORK (PHASE I)** **L T P C**
0 0 12 6

PX7411 **PROJECT WORK (PHASE II)** **L T P C**
0 0 24 12

PS7005 **HIGH VOLTAGE DIRECT CURRENT TRANSMISSION** **L T P C**
3 0 0 3

UNIT I DC POWER TRANSMISSION TECHNOLOGY
6

Introduction - Comparison of AC and DC transmission – Application of DC transmission – Description of DC transmission system - Planning for HVDC transmission – Modern trends in DC transmission – DC breakers – Cables, VSC based HVDC.

UNIT II ANALYSIS OF HVDC CONVERTERS AND HVDC SYSTEM CONTROL
1
2

Pulse number, choice of converter configuration – Simplified analysis of Graetz circuit - Converter bridge characteristics – characteristics of a twelve pulse converter- detailed analysis of converters. General principles of DC link control – Converter control characteristics – System control hierarchy - Firing angle control – Current and extinction angle control – Generation of harmonics and filtering - power control – Higher level controllers.

UNIT III MULTITERMINAL DC SYSTEMS **9**

Introduction – Potential applications of MTDC systems - Types of MTDC systems - Control andprotection of MTDC systems - Study of MTDC systems.

UNIT IV POWER FLOW ANALYSIS IN AC/DC SYSTEMS **9**

Per unit system for DC Quantities - Modelling of DC links - Solution of DC load flow - Solution ofAC-DC power flow – Unified, Sequential and Substitution of power injection method.

UNIT V SIMULATION OF HVDC SYSTEMS **9**

Introduction – DC LINK Modelling , Converter Modeling and State Space Analysis , Philosophyand tools – HVDC system simulation, Online and OFFline simulators —- Dynamic interactions between DC and AC systems.

TOTAL: 45 PERIODS

REFERENCES

1. P. Kundur, "Power System Stability and Control", McGraw-Hill, 1993
2. K.R.Padiyar, , "HVDC Power Transmission Systems", New Age International (P) Ltd., NewDelhi, 2002.
3. J.Arrillaga, , "High Voltage Direct Current Transmission", Peter Pregrinus, London, 1983.
4. Erich Uhlmann, " Power Transmission by Direct Current", BS Publications, 2004.
5. V.K.Sood,HVDC and FACTS controllers – Applications of Static Converters in PowerSystem, APRIL 2004 , Kluwer Academic Publishers.

PS7004 SOLAR AND ENERGY STORAGE SYSTEMS

L T P C
3 0 0 3

UNIT I INTRODUCTION **9**

Characteristics of sunlight – semiconductors and P-N junctions –behavior of solar cells –cellproperties – PV cell interconnection

UNIT II STAND ALONE PV SYSTEM **9**

Solar modules – storage systems – power conditioning and regulation - protection – stand alonePV systems design – sizing

UNIT III GRID CONNECTED PV SYSTEMS **9**

PV systems in buildings – design issues for central power stations – safety – Economic aspect –Efficiency and performance - International PV programs

UNIT IV ENERGY STORAGE SYSTEMS **9**

Impact of intermittent generation – Battery energy storage – solar thermal energy storage –pumped hydroelectric energy storage

UNIT V APPLICATIONS **9**

Water pumping – battery chargers – solar car – direct-drive applications –Space – Telecommunications.

TOTAL : 45 PERIODS

REFERENCES:

1. Eduardo Lorenzo G. Araujo, Solar electricity engineering of photovoltaic systems,Progensa,1994.
2. Stuart R.Wenham, Martin A.Green, Muriel E. Watt and Richard Corkish, AppliedPhotovoltaics, 2007,Earthscan, UK.
3. Frank S. Barnes & Jonah G. Levine, Large Energy storage Systems Handbook ,CRC Press, 2011.
4. Solar & Wind Energy Technologies – McNeils, Frenkel, Desai, Wiley Eastern, 1990
5. Solar Energy – S.P. Sukhatme, Tata McGraw Hill,1987.