SETHU INSTITUTE OF TECHNOLOGY

PULLOOR, KARIAPATTI – 626 115.

(AN AUTONOMOUS INSTITUTION)

REGULATION – 2015

M.E POWER ELECTRONICS AND DRIVES

CURRICULUM & SYLLABUS

Approved in the Academic Council Meeting held on 06.10.2016

Chairman of Board of Studies
Chairperson
Board of Studies
Electrical & Electronics Engineering
Sethu Institute of Technology
Kariapatti - 626 115

Chairman of Academic Council
CHAIRMAN
ACADEMIC COUNCIL
Sethu Institute of Technology
Pulloor, Kariapatti - 625 115

Vision of the Department

To achieve Excellence in Education and Research in the field of Electrical and Electronics Engineering and provide knowledge based contribution for the development of economy and society

Mission of the Department

- Providing comprehensive and value based education in Electrical and Electronics engineering and related fields to meet intellectual, ethical and career challenges
- Providing state-of- the-art infrastructure and resources to promote teaching-learning and research activities
- Enriching the skills to enhance employability and entrepreneurship
- Strengthening the collaboration with academia, industry and research organizations
- Fostering Research and Development activities leading to innovation and technological growth in the overall ambit of electrical and electronics engineering
- Offering services to the society through education, science and technology

CORE VALUES: Ethics | Quality | Innovation | Teamwork | Social Responsibility

Program Educational Objectives (PEOs)

The graduates of Electrical and Electronics Engineering are expected to:	
PEO I (Core Competency)	Exhibit technical competency in Electrical and Electronics Engineering and related fields
PEO II (Life Long Learning)	Engage in life-long learning for professional development and research
PEO III (Professional and Ethical Skills)	Exhibit effective communication skills, team work and lead their profession with ethics

Program Outcomes

PO1. Engineering knowledge: Apply the knowledge of mathematics, science, electrical and electronics engineering fundamentals to the solution of complex engineering problems.

PO2. Problem analysis: Identify, formulate, review research literature, and analyze complex electrical and electronics engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/Development of solutions: Design and develop electrical and electronic systems that meet specified needs with appropriate consideration for public health and safety, cultural, societal and environmental considerations.

PO4. Investigation of complex problems: Investigate and analyze complex electrical and electronics engineering problems using research-based knowledge and research methods including design of experiments, analysis and interpretation of data and synthesis of information to provide valid conclusions.

PO5. Modern tool usage: Select and apply modern engineering and IT tools for simulation and modeling of electrical and electronic systems.

PO6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities to the professional engineering practice.

PO7. Environment and sustainability: Understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.

PO9. Individual and teamwork: Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations and give and receive clear instructions.

PO11. Project management and Finance: Demonstrate knowledge and understanding of engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-long learning: Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

SETHU INSTITUTE OF TECHNOLOGY

Pulloor, Kariapatti - 626 115

M.E. Degree Programme (Full Time)

CURRICULUM

Regulation 2015

Master of Engineering in Power Electronics and Drives

OVERALL COURSE STRUCTURE

Category	Total No. of Courses	Credits	Percentage
Basic Science	**1**	**4**	**6**
Programme-CORE	**11**	**28**	**41**
Programme- ELECTIVE	**5**	**15**	**22**
Open Elective	**1**	**3**	**4**
Project Work	**2**	**18**	**27**
TOTAL	**20**	**68**	**100**

COURSE CREDITS – SEMESTER WISE

Branch	I	II	III	IV	TOTAL
ME-PED	**18**	**17**	**18**	**15**	**68**

M.E POWER ELECTRONICS AND DRIVES

REGULATION – 2015

(Applicable to the students admitted from the Academic Year 2015 – 2016 onwards)

CURRICULUM I TO IV SEMESTERS (FULL TIME)

SEMESTER I

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	15PMA126	Applied Mathematics for Electrical Engineers	3	1	0	4
2.	15PPE101	Analysis of Electrical Machines	3	1	0	4
3.	15PPE102	Analysis of Power Converters	3	0	0	3
4.	15PPE103	Modern Power Semiconductor Devices	3	0	0	3
5.	-	Elective-I	3	0	0	3
PRACTICAL						
6.	15PPE104	Power Electronics & Drives Laboratory -I	0	0	3	1
Total			15	2	3	18
Total Number of Credits: 18						

SEMESTER II

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	15PPE201	Analysis of Inverters	3	0	0	3
2.	15PPE202	DC Drives and Control	3	0	0	3
3.	15PPE203	AC Drives and Control	3	0	0	3
4.	-	Elective-II	3	0	0	3
5.	-	Elective-III	3	0	0	3
PRACTICAL						
6.	15PPE204	Power Electronics & Drives Laboratory-II	0	0	3	1
7.	15PPE205	Internship/Industrial Training*	0	0	2	1
Total			15	0	5	17
Total Number of Credits: 17						

* (The students should attend the internship/industrial training at industry or reputed institution or any other research centre of 1 week or 2 week during vacation period of first semester. (OR) The students should accommodate in the UG programme laboratory for internship training in second semester. The internship/industrial training will be evaluated based on the presentation in the seminar and reports.)

SEMESTER III

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	15PPE301	Special Electrical Machines and Controllers	3	0	0	3
2.	15PPE302	Digital Controllers in Power Electronics Application	3	0	0	3
3.	-	Elective-IV	3	0	0	3
4.	-	Elective-V	3	0	0	3
5.	-	Open Elective	3	0	0	3
PRACTICAL						
6.	15PPE303	Project Work (Phase-I)	0	0	6	3
Total			15	0	6	18
Total Number of Credits: 18						

SEMESTER IV

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
PRACTICAL						
1.	15PPE401	Project Work (Phase-II)	0	0	30	15
Total			0	0	30	15
Total Number of Credits: 15						

TOTAL NO. OF CREDITS: 68

SETHU INSTITUTE OF TECHNOLOGY

Pulloor, Kariapatti - 626 115

M.E. Degree Programme (Part-Time)

CURRICULUM

Regulation 2015

Master of Engineering in Power Electronics and Drives

OVERALL COURSE STRUCTURE

Category	Total No. of Courses	Credits	Percentage
Basic Science	**1**	**4**	**6**
Programme-CORE	**11**	**28**	**41**
Programme- ELECTIVE	**5**	**15**	**22**
Open Elective	**1**	**3**	**4**
Project Work	**2**	**18**	**27**
TOTAL	**20**	**68**	**100**

COURSE CREDITS – SEMESTER WISE

Branch	I	II	III	IV	V	VI	TOTAL
ME-PED	**11**	**09**	**10**	**11**	**12**	**15**	**68**

M.E POWER ELECTRONICS AND DRIVES

REGULATION – 2015

(Applicable to the students admitted from the Academic Year 2015 – 2016 onwards)

CURRICULUM I TO VI SEMESTERS (PART-TIME)

SEMESTER I

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	15PMA126	Applied Mathematics for Electrical Engineers	3	1	0	4
2.	15PPE101	Analysis of Electrical Machines	3	1	0	4
3.	-	Elective -I	3	0	0	3
Total			9	2	0	11
Total Number of Credits: 11						

SEMESTER II

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	15PPE201	Analysis of Inverters	3	0	0	3
2.	15PPE202	DC Drives and Control	3	0	0	3
3.	-	Elective -II	3	0	0	3
Total			9	0	0	9
Total Number of Credits: 09						

SEMESTER III

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	15PPE102	Analysis of Power Converters	3	0	0	3
2.	15PPE103	Modern Power Semi Conductor Devices	3	0	0	3
3.	-	Elective-III	3	0	0	3
PRACTICAL						
4.	15PPE104	Power Electronics & Drives Laboratory -I	0	0	3	1
Total			9	0	3	10
Total Number of Credits: 10						

SEMESTER IV

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	15PPE203	AC Drives and Control	3	0	0	3
2.	-	Elective-IV	3	0	0	3
3.	-	Elective-V	3	0	0	3
PRACTICAL						
4.	15PPE204	Power Electronics and Drives Laboratory - II	0	0	3	1
5.	15PPE205	Internship /Industrial Training*	0	0	2	1
Total			9	0	5	11
Total Number of Credits: 11						

* (The students should attend the internship/industrial training at industry or reputed institution or any other research centre of 1 week or 2 week during vacation period of first semester. (OR) The students should accommodate in the UG programme laboratory for internship training in second semester. The internship/industrial training will be evaluated based on the presentation in the seminar and reports.)

SEMESTER V

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	15PPE301	Special Electrical Machines and Controllers	3	0	0	3
2.	15PPE302	Digital Controllers in Power Electronics Application	3	0	0	3
3.	-	Open Elective	3	0	0	3
PRACTICAL						
4.	15PPE303	Project Work (Phase-I)	0	0	6	3
Total			9	0	6	12
Total Number of Credits: 12						

SEMESTER VI

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
PRACTICAL						
1.	15PPE401	Project Work (Phase-II)	0	0	30	15
Total			0	0	30	15
Total Number Of Credits: 15						

TOTAL NO. OF CREDITS: 68

LIST OF ELECTIVES

SL.NO	COURSE CODE	COURSE TITLE
1.	15PPE501	Power Electronics for PV and Wind Energy Systems
2.	15PPE502	Digital Simulation of Power Electronic Systems
3.	15PPE503	HVDC Systems and Control
4.	15PPE504	Electromagnetic Field Computation and Modeling
5.	15PPE505	Computer aided design of Power Electronics Circuits
6.	15PPE506	Electric Vehicles and Power Management
7.	15PPE507	Power Controllers in Power Systems
8.	15PPE508	Electric Power Quality
9.	15PPE509	Linear and Non-Linear System Theory
10.	15PPE510	Solar and Energy Storage System
11.	15PPE511	Microcontroller Application in Power Converters
12.	15PPE512	Switched Mode Power Conversion
13.	15PPE513	Modern Rectifiers and Resonant Converters
14.	15PPE514	Micro Electro Mechanical Systems
15.	15PPE515	Wind Energy Conversion Systems
16.	15PPE516	VLSI Architecture and Design Methodologies
17.	15PPE517	Nanomaterials and Energy Systems
18.	15PPE518	Non Linear Dynamics of Power Electronic Circuits
19.	15PPE519	Electromagnetic Interference and Electromagnetic Compatibility
20.	15PPE520	Smart Grid
21.	15PPE521	Distributed Generation and Micro Grid
22.	15PPE522	Transient Over Voltages in Power Systems
23.	15PPE523	Restructured Power System
24.	15PPE524	Optimization Techniques in Power Electronics

LIST OF OPEN ELECTIVES

SL.NO	COURSE CODE	COURSE TITLE
1.	15PSE601	Research Methodology
2.	15PEN602	Pedagogy
3.	15PEN603	Professional and Communication Skill
4.	15PPE604	Soft Computing
5.	15PCD605	Industrial Safety
6.	15PCD606	Business Management and Leadership
7.	15PCS607	Management Information System

LIST OF ELECTIVES (for Ph.D.Scholars)

SL.NO	COURSE CODE	COURSE TITLE
1.	15PPE525	Energy Management and Auditing
2.	15PPE526	Analysis and Modeling of Digital System using VHDL
3.	15PPE527	Design and Control of Switched Reluctance Machine for Automotive Applications
4.	15PPE528	Recent techniques for Reliable Distribution System
5.	15PPE529	Application of Intelligent Controllers for Power Quality Improvement

SEMESTER I

SEMESTER I

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	15PMA126	Applied Mathematics for Electrical Engineers	3	1	0	4
2.	15PPE101	Analysis of Electrical Machines	3	1	0	4
3.	15PPE102	Analysis of Power Converters	3	0	0	3
4.	15PPE103	Modern Power Semiconductor Devices	3	0	0	3
5.	-	Elective-I	3	0	0	3
PRACTICAL						
6.	15PPE104	Power Electronics & Drives Laboratory -I	0	0	3	1
Total			15	2	3	17
Total Number of Credits: 17						

SYLLABUS

15PMA126	APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERS	L	T	P	C
		3	1	0	4

OBJECTIVES:

- To develop the ability to apply the concepts of Matrix theory and linear programming in Electrical Engineering problems.
- To achieve an understanding of the basic concepts of one dimensional random variables and apply in electrical engineering problems.
- To familiarize the students in calculus of variations and solve problems using Fourier series associated with engineering applications.

UNIT I MATRIX THEORY 9+3

The Cholesky decomposition - Generalized Eigen vectors, Canonical basis - QR factorization - Least squares method - Singular value decomposition.

UNIT II LINEAR PROGRAMMING 9+3

Formulation – Graphical solution – Simplex method – Two phase method - Transportation and Assignment Models.

UNIT III ONE DIMENSIONAL RANDOM VARIABLES 9+3

Random variables - Probability function - Moments - Moment generating functions and their properties - Binomial, Poisson, Normal, Geometric, Uniform, Exponential and Gamma distributions - Functions of a Random Variable.

UNIT IV FAST FOURIER TRANSFORM 9+3

Discrete convolution- Periodic sequence and circular convolution- Linear convolution through circular convolution – Discrete Fourier series and discrete Fourier transform – Fast Fourier transform – Decimation in time algorithm, decimation in frequency algorithm - Computation of inverse DFT.

UNIT V NUMERICAL TECHNIQUES 9+3

Boundary value problems for ODE - Finite Difference methods - Numerical solution of PDE - Solution of Laplace and Poisson equations – Solution of heat conduction by Schmidt explicit formula and Crank-Nicolson implicit scheme - Solution of wave equations – Concept of variation and its properties - Euler's equation.

TOTAL: 45(L)+15(T):60 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to :

- Enrich the knowledge of Decomposition of Matrix.
- Solve Euler equations numerically with moving boundaries.
- Analyze the process of communication involves various operations such as modulation, detection, filtering by using random variable techniques.
- Analyze the process of inverter and converter
- Operate point selections, local parameterization, weighted least squares fitting by using finite difference method.

REFERENCES:

1. Richard Bronson , "Matrix Operation", Schanum's Outline Series ,McGraw Hill, 2nd Edition, New Delhi, 2011.
2. Taha H. A, "Operations Research: An introduction", Pearson Education Edition, Ninth Edition, New Delhi, 2011.
3. Veerarajan T., " Engineering Mathematics", Tata McGraw Hill Publications, New Delhi, 5th Edition, 2006.
4. Oliver C. IBE, "Fundamentals of Applied Probability and Random Processes", Lowell, Massachusetts, 1st Edition, Indian reprint, 2010.
5. Andrews L.C. and PHILLIPS R.L, "Mathematical Techniques for Engineers and Scientists", Prentice Hall of India, 1st Edition, New Delhi, 2003.

15PPE101	ANALYSIS OF ELECTRICAL MACHINES	L	T	P	C
		3	1	0	4

OBJECTIVES:

- To outline the electromagnetic energy conversion, energy, force /torque of single and doubly excited systems.
- To impart the knowledge on theory of transformation of three phase variables to two phase Variables.
- To review the performance of AC and DC machines.

UNIT I ELECTROMAGNETIC ENERGY CONVERSION 9+3

Principles of Electromagnetic Energy Conversion -General expression of stored magnetic energy, co-energy and force/ torque – example using single and doubly excited system. Basic Concepts of Rotating Machines-Calculation of air gap MMF and per phase machine inductance using physical machine data.

UNIT II REFERENCE FRAME THEORY 9+3

Static and rotating reference frames – transformation of variables – reference frames – transformation between reference frames - transformation of a balanced set -balanced steady state phasor and voltage equations – variables observed from several frames of reference.

UNIT III ANALYSIS OF DC MACHINES 9+3

Voltage and torque equation of dc machine, dynamic characteristics of permanent magnet and shunt DC motors – state equations - solution of dynamic characteristic by Laplace transformation.

UNIT IV ANALYSIS OF INDUCTION MACHINES 9+3

Voltage and torque equations - transformation for rotor circuits - voltage and torque equations in reference frame variables - analysis of steady state operation - free acceleration characteristics - dynamic performance for load and torque variations **– Performance analysis of three phase squirrel cage Induction Motor using MAXWELL RMxprt Software(ANSYS)** .

UNIT V ANALYSIS OF SYNCHRONOUS MACHINES 9+3

Voltage Equation in arbitrary reference frame and rotor reference frame - Park equations - rotor angle and angle between rotor - steady state analysis - dynamic performances for torque variations-computer simulation.

TOTAL:45(L)+15(T) :60 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to :

- Analyze the different electrical machines used for industrial drive applications**.**
- Analyze the steady state and dynamic state operation of three-phase induction machines and synchronous machines using transformation theory based mathematical modelling and simulation in digital computer.
- Analyze the steady state and dynamic state operation of DC machine through mathematical modelling and simulation in digital computer.
- Calculate the air gap MMF and per phase machine inductance using physical machine data.
- Write the state equations for DC machines.

REFERENCES:

1. Paul C. Krause, Oleg Wasyzczuk, Scott S, Sudhoff, “Analysis of Electric Machinery and Drive Systems”, IEEE Press, Second Edition, 2005.
2. Charles Kingsley Jr, Fitzgerald A.E, Stephen D. Umans, “Electric Machinery”, Tata McGraw Hill, Sixth Edition, 2003.
3. Ned Mohan, “Advanced electrical drives Analysis, Control and Modeling using Simulink”, MNPERE, USA, 2001.
4. Krishnan. R, “Electric Motor Drives, Modeling, Analysis and Control”, Prentice Hall of India, 2005.
5. Samuel Seely, “Electromechanical Energy Conversion”, Tata McGraw Hill Publishing Company, New York 1962.

15PPE102 **ANALYSIS OF POWER CONVERTERS**

L	T	P	C
3	0	0	3

OBJECTIVES:

- To provide the electronics circuits concepts behind the different working modes of power converters so as to enable deep understanding of their operation.
- To equip with required skills to derive the criteria for the design of power converters starting from basic fundamentals.
- To explain various operating modes of different configurations of power converters.

UNIT I SINGLE PHASE CONTROLLED RECTIFIERS **9**

Introduction-half controlled and fully controlled converters with R, R-L, R-L-E loads and freewheeling diodes – continuous and discontinuous modes of operation - inverter operation – 1Φ Dual converter - Sequence control of converters -performance parameters: harmonics, ripple, distortion, power factor – effect of source impedance and overlap-Single phase series Converter.

UNIT II THREE PHASE CONTROLLED RECTIFIERS **9**

Three phase Half and Fully controlled converter with R, R-L, R-L-E - loads and freewheeling diodes -inverter operation and its limit - Performance parameters of 3phase full Converters -3Φ Dual Converter-effect of source impedance and overlap – 12 pulse converter-Power Factor Improvements.

UNIT III DC –DC CONVERTERS **9**

Introduction – Principles of step-down and Step-up operation with R & RL Load-Classification of Converter-Switching mode regulators- time ratio and current limit control -Analysis of buck, boost, buck-boost and Cuk converters- Comparison of regulators -Resonant and quasi resonantconverters- **sepic converters – super lift converters-zeta converters-Applications.**

UNIT IV AC VOLTAGE CONTROLLERS **9**

Introduction - Principle of phase control-Analysis of single phase controllers with R &RL Load-Three phase controllers-Y and Δ Configuration -Matrix Converter-Effect of Source and load inductances.

UNIT V CYCLOCONVERTERS **9**

Introduction- Single phase and three phase Cycloconverters- Reduction of output Harmonics-Load Commutated Cycloconverter.

TOTAL: 45 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to :

- Analyze the various operating modes of different configurations of Power converters.
- Design different power converters namely AC to DC, DC to DC and AC to AC converters**.**
- Compare different types of Regulators**.**
- Compute the performance parameters for power converters.
- Explain the effect of source inductance and load inductance of power converters.

REFERENCES:

1. Rashid M.H, “Power Electronics Circuits, Devices and Applications”, Prentice Hall India, Third edition, New Delhi, 2008.

2. Bimbra P.S, “Power Electronics”, Khanna Publishers, Eleventh Edition, 2003.
3. Ned Mohan, Undeland and Robbin , “Power Electronics: converters, Application and design”, John Wiley and sons. Inc, Third edition, Newyork, 2007.
4. Cyril W. Lander, “Power Electronics”, McGraw hill, Third Edition, 1993.
5. Sen P.C, “ Modern Power Electronics ”, Wheeler publishing Co, First Edition, New Delhi, 1998.
6. Singh M.D, Khanchandani K. B, “Power Electronics”, Tata McGraw Hill Publishing Company Limited, 2nd Edition, 2009.

15PPE103 MODERN POWER SEMICONDUCTOR DEVICES

L	T	P	C
3	0	0	3

OBJECTIVES:

- To explain static and dynamic characteristics of current controlled power semiconductor devices.
- Give knowledge on firing and protection circuits.
- To review the concepts of control and firing circuit for different devices

UNIT I INTRODUCTION OF POWER SEMICONDUCTOR DEVICES 9

Overview of Power switching devices -Attributes of an ideal switch, application requirements, circuit symbols; Power handling capability - Safe Operating Area (SOA);Characteristics and Specifications of Switches - Device selection strategy – On state and switching losses – EMI- Power diodes - Types, Diode Characteristics-Reverse Recovery Characteristics-Rating of Switches.

UNIT II CURRENT CONTROLLED DEVICES 9

BJT's – Construction, Steady State characteristics, switching characteristics, Switching limits; Negative temperature co-efficient and secondary breakdown; Power Darlington Connection. Thyristors - Construction and operating mode, Two transistor analogy - concept of latching; Gate & switching characteristics; converter grade and inverter grade and other types; series and parallel operation; comparison of BJT and Thyristor - steady state and dynamic models of BJT & Thyristor.

UNIT III VOLTAGE CONTROLLED DEVICES 9

Power MOSFETs and IGBTs – Principle, construction, types, steady state and switching characteristics, steady state and dynamic models of MOSFET and IGBTs – Characteristics of TRAIC & GTO -Basics of MCT, FCT, RCT and IGCT-Comparison.

UNIT IV DRIVING AND PROTECTION CIRCUITS 9

Necessity of isolation, pulse transformer, Opto-coupler - Gate drives circuit: SCR, MOSFET, IGBTs and base driving for power BJT - Over voltage, over current and gate protections; Need of snubber circuit – Types of snubber -Design of snubbers.

UNIT V THERMAL PROTECTION 9

Heat transfer - conduction, convection and radiation; Cooling - liquid cooling, vapour - phase cooling; Guidance for heat sink selection - Thermal resistance and impedance -Thermal Modeling of Power Switching Devices, heat sink types and design - Mounting types.

TOTAL: 45 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to:

- Explain the construction and operation of advanced power semiconductor devices.
- Compare voltage and current controlled devices.
- Select the suitable device for different power electronics applications.
- Design various protection circuits for power converter circuits.
- Design the snubber circuits for Power converters.

REFERENCES:

1. Williams B.W, "Power Electronics Circuit Devices and Applications", Macmillan Education Ltd, 2007.
2. Rashid M.H, "Power Electronics Circuits, Devices and Applications", Prentice Hall India, New Delhi, 2008.
3. Singh M.D, Khanchandani K.B, "Power Electronics", Tata McGraw Hill, 2001.
4. Ned Mohan, Undcland and Robins, " Power Electronics – Concepts, applications and Design ", John Wiley and Sons, Singapore, 2000.

15PPE104 POWER ELECTRONICS AND DRIVES LABORATORY – I

L	T	P	C
0	0	3	2

OBJECTIVES:

- To train the students with knowledge of the principle of operation of power converter and inverter circuits.
- To simulate different power converters studied in the core courses on power converters.

LIST OF EXPERIMENTS*

1. Single phase half and fully controlled converter with lamp load
2. Three phase fully controlled converter with lamp load.
3. Design and simulation of DC-DC Choppers -Buck, Boost, Buck-Boost.
4. IGBT based single-phase PWM inverter.
5. IGBT based Three-phase PWM inverter.
6. Resonant DC to DC Converter.
7. Step down and Step-up MOSFET based Chopper
8. Simulation of Single phase Semi controlled converter with
    a) R Load
    b) RL load.
    c) RLE (Motor) Load
9. Simulation of Single phase fully controlled converter with
    a) R Load.
    b) RL load.
    c) RLE (Motor) Load using MATLAB & PSIM.
10. Simulation of three phase half controlled converter with
    a) R Load.
    b) RL load.
    c) RLE (Motor) Load
11. Simulation of single phase and three phase AC Voltage Controller.
    a) Lamp load
    b) Motor load
12. Simulation of(i) LC tank circuit resonance using MATLAB & PSIM
    ii) Basic / modified series inverter
    iii) Series loaded series resonant inverter
13. Design and simulation of snubber circuit.

TOTAL: 45 Periods

*MINIMUM OF 10 EXPERIMENTS SHOULD BE OFFERED

COURSE OUTCOMES:

After successful completion of this course the students will be able to:

- Analyze the performance and operation of power converter circuits.
- Test the power converter and inverter circuits.
- Experiment the AC and DC machines with open loop and closed loop control.
- Design and simulate snubber circuit.
- Design DC-DC Converters.

SEMESTER II

SEMESTER-II

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	15PPE201	Analysis of Inverters	3	0	0	3
2.	15PPE202	DC Drives and Control	3	0	0	3
3.	15PPE203	AC Drives and Control	3	0	0	3
4.	-	Elective-II	3	0	0	3
5.	-	Elective-III	3	0	0	3
6.	15PPE204	Internship/Industrial Training	0	1	2	1
PRACTICAL						
7.	15PPE205	Power Electronic & Drives Laboratory-II	0	0	3	1
Total			15	1	5	17
Total Number of Credits: 17						

15PPE201 **ANALYSIS OF INVERTERS**

L	T	P	C
3	0	0	3

OBJECTIVES:

- To provide the electrical circuit concepts behind the different working modes of inverters and to enable deep understanding of their operation.
- To review the concept of multilevel inverters.
- To outline the concepts of resonant pulse inverters.

UNIT I SINGLE PHASE VOLTAGE SOURCE INVERTERS 9

Introduction - Principle of operation of half and full bridge inverters - Performance parameters - Voltage control of single phase inverters using various PWM techniques - various harmonic elimination techniques – forced commutated thyristor inverters.

UNIT II THREE PHASE VOLTAGE SOURCE INVERTERS 9

180 degree and 120 degree conduction mode inverters with star and delta connected loads - voltage control of three phase inverters: single, multi pulse, sinusoidal, space vector modulation techniques. -Comparison of PWM Techniques.

UNIT III CURRENT SOURCE INVERTERS 9

Single phase CSI - Three phase CSI: Operation of six-step thyristor inverter - inverter operation modes - load commutated inverters - Auto sequential current source inverter (ASCI) - current pulsations – comparison of CSI and VSI.

UNIT IV MULTILEVEL INVERTERS 9

Introduction-Multilevel Concept-Types: Diode Clamped-Flying Capacitor-Cascaded. Applications- DC link capacitor voltage balancing-Features of Multilevel Inverters-Comparison of multilevel inverters.

UNIT V RESONANT PULSE INVERTERS 9

Series and parallel resonant inverters –Frequency response of series resonant inverters- voltage control of resonant inverters - Class E resonant inverter - resonant DC - link inverters.

TOTAL: 45 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to :

- Analyze the various operating modes of configuration of VSI and CSI inverter circuits.
- Compare different types of PWM techniques.
- Design different single phase and three phase inverters.
- Explain different types of multilevel inverters.
- Differentiate the types of Resonant Pulse inverters.

REFERENCES:

1. Rashid M.H, “Power Electronics: Circuits, Devices and Applications”, Prentice Hall India, New Delhi, 2008.
2. Bimbhra. P.S, “Power Electronics,” Khanna Publishers, Eleventh Edition, 2003.
3. Jai P.Agrawal, “Power Electronics Systems: Theory and Design”, Pearson Education, Second Edition, 2002.
4. Bimal K.Bose, “ Modern Power Electronics and AC Drives ”, Pearson Education, Second Edition, 2003

5. Ned Mohan, Undeland and Robbins, “Power Electronics: converters, Application and design”, John Wiley and sons. Inc, Newyork, 2007.
6. Sen P.C, “ Modern Power Electronics ”, Wheeler Publishing Co, First Edition, New Delhi, 1998 .

15PPE202	DC DRIVES AND CONTROL	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To explain the steady state operation and transient behaviour of electrical drives.
- To impart the implementation of control algorithms using microcontrollers and phase locked loop.
- To review the current and speed controllers for a closed loop solid state DC motor drives.

UNIT I FUNDAMENTALS OF ELECTRICAL DRIVES 9

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. Starting and Braking. Characteristics of mechanical system – dynamic equations, components of torque, Nature and Classification of Load Torques- types of load; Requirements of drives characteristics – multi-quadrant operation; Drive elements, types of motor duty and selection of motor rating.

UNIT II RECTIFIER CONTROL OF DC MOTORS 9

Analysis of series and separately excited DC motor with single phase and three phase converters operation in continuous and discontinuous mode, performance parameters, performance characteristics, Operation with Freewheeling diode; Implementation of braking schemes; Drive employing dual converter. Armature current ripple and its effect- Multi quadrant Operation, Pulse width modulated Rectifiers.

UNIT III CHOPPER CONTROL OF DC DRIVES 9

Class A, B, C, D and E chopper controlled DC motor – performance analysis, Chopper based implementation of braking schemes; Multi-phase chopper**- PV fed DC drives**

UNIT IV CLOSED LOOP CONTROL OF DC DRIVES 9

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. Single Quadrant and four quadrant variable speed drives- Simulation of converter and chopper fed DC drive.

UNIT V DIGITAL CONTROL OF DC DRIVE 9

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

TOTAL: 45 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to :

- Explain the basic concept of steady state operation and transient dynamics of a motor load system.
- Analyze the operation of various converter /chopper fed DC drives.
- Analyze the current and speed controllers for a closed loop DC drives.
- Solve the problem of converter /chopper fed DC drives.
- Design the current and speed controllers for a closed loop DC motor drives.

REFERENCES:

1. Gopal K Dubey, "Power Semiconductor controlled Drives", Prentice Hall Inc, New Yersy, 1989.
2. Krishnan R, "Electric Motor Drives – Modeling, Analysis and Control", Prentice-Hall of India Pvt. Ltd, New Delhi, 2003.
3. Gobal K.Dubey, "Fundamentals of Electrical Drives", Narosal Publishing House, New Delhi, 2001.
4. Bimal K.Bose, "Modern Power Electronics and AC Drives", Pearson Education (Singapore) Pte. Ltd, New Delhi, 2003.
5. Vedam Subramanyam, "Electric Drives – Concepts and Applications", Tata McGraw-Hill publishing company Ltd, New Delhi, 2002.
6. Sen P.C, "Thyristor DC Drives", John wiely and sons, New York, 1981.

15PPE203	AC DRIVES AND CONTROL	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To explain the principles of modern control techniques for AC drives.
- To provide a strong background on various methods of speed control of AC machines.
- Give on knowledge on field oriented control of induction machine.

UNIT I CONVENTIONAL CONTROL OF INDUCTION MOTORS 9

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

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

UNIT III SLIP POWER CONTROLLED INDUCTION MOTOR DRIVE 9

Static rotor resistance control- injection of voltage in the rotor circuit- static scherbius drives: power factor considerations, analysis and equivalent circuit- Applications-modified Kramer drives.

UNIT IV VECTOR ORIENTED CONTROL 9

Principle of vector control – DC drive analogy – Direct and Indirect methods -Tuning of the vector controller- 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

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

TOTAL: 45 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to :

- Discuss the operation of various speed controls in AC drives.
- Explain starting and braking schemes in AC drives.
- Analyze the performance of AC drives.
- Apply different types of control techniques to AC drives.
- Analyze the operation of VSI & CSI fed induction motor control.

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, Second Edition, 1994.
3. Gopal K Dubey, “Power Semiconductor controlled Drives”, Prentice Hall Inc, New Yersy, 1989.

4. Krishnan R, “Electric Motor Drives – Modeling, Analysis and Control”, Prentice-Hall of India Pvt. Ltd, New Delhi, 2003.
5. Leonhard W, “Control of Electrical Drives”, Narosa Publishing House, New Delhi, 1992.
6. Murphy J.M.D, Turnbull, “Thyristor Control of AC Motors”, Pergamon Press, Oxford, 1988.

15PPE204 **INTERNSHIP/INDUSTRIAL TRAINING**

L	T	P	C
0	1	2	1

OBJECTIVES:

- To provide hands-on training at industry or reputed institution or any research centre where Power Electronics Engineering projects are carried out.
- To provide practical application of theoretical concepts studied in the class rooms.

ASSESSMENT PROCESS *

- Students have to undergo one or two week practical training in Power Electronics Engineering related project at industry or a company or research centre of their choice but with the approval of the department. At the end of the training student will submit a report as per the prescribed format to the department.

- This course is mandatory and the student has to pass the course to become eligible for the award of degree. The student shall make a presentation before a committee constituted by the department which will assess the student based on the report submitted and the presentation made and award either a P or U. The student with 'U' grade will redo the training.

COURSE OUTCOMES:

After successful completion of this course the students will be able to:

- Explore the preferred field of specialization.
- Develop analytical / hardware / software / experimental skills.
- Manage the technical content and work.
- Prepare and present technical report.
- Apply practical knowledge to their project work.

15PPE205 POWER ELECTRONICS AND DRIVES LABORATORY - II

L	T	P	C
0	0	3	2

OBJECTIVES:

- To demonstrate the speed control of the chopper/converter fed DC drives.
- To train the students to control the electrical drives using digital controllers.

LIST OF EXPERIMENTS*

1. Micro controller based speed control of Chopper /Converter fed DC motor.
2. Micro controller based speed control of VSI fed three-phase induction motor.
3. Micro controller based speed control of Stepper motor.
4. DSP based speed control of BLDC motor.
5. Control of BUCK-BOOST Converter Using FPGA.
6. Design of switched mode power supplies.
7. Re-programmable Logic Devices and Programming
   (i) VHDL programming - Examples.
   (ii) Verilog HDL programming - Examples.
   (iii) Realization of control logic for electric motors using FPGA.
8. Simulation of Four quadrant operation of three-phase induction motor.
9. Simulation of VSI fed three phase induction motor.
10. Simulations of Speed regulation of three phase synchronous generator.
11. DSP based speed control of SRM motor.
12. Self control operation of Synchronous motors.
13. Condition monitoring of three-phase induction motor under fault conditions.
14. Performance analysis of three phase squirrel cage Induction Motor using MAXWELL RMxprt Software (ANSYS).

TOTAL: 45 Periods

*MINIMUM OF 10 EXPERIMENTS SHOULD BE OFFERED

COURSE OUTCOMES:

After successful completion of this course the students will be able to:

- Explain the speed control of electrical machines with experimental results.
- Write VHDL and FPGA program for digital logic circuits.
- Experiment in electrical machines with closed loop control using DSP.
- Experiment AC drives using MATLAB and ANSYS.
- Control the electrical machine with digital controllers.

SEMESTER-III

SEMESTER III

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	15PPE301	Special Electrical Machines and Controllers	3	0	0	3
2.	15PPE302	Digital Controllers in Power Electronics Application	3	0	0	3
3.	-	Elective-IV	3	0	0	3
4.	-	Elective-V	3	0	0	3
5.	-	Open Elective	3	0	0	3
PRACTICAL						
6.	15PPE303	Project Work (Phase-I)	0	0	6	3
Total			15	0	6	18
Total Number of Credits: 18						

15PPE301 SPECIAL ELECTRICAL MACHINES AND CONTROLLERS

L	T	P	C
3	0	0	3

OBJECTIVES:

- To explain the constructional features principle of operation and mode of excitation of various special electrical machines.
- To make aware the students on various aspects of special electrical machines and their controllers.
- To introduce the concepts of stepper motors and its applications.

UNIT I PERMANENT MAGNET BRUSHLESS DC MOTORS 9

Fundamentals of Permanent Magnets- Types- Principle of operation- Magnetic circuit analysis-EMF and Torque equations- Characteristics - Difference between mechanical and electronic commutators, Hall sensors, Optical sensors, Multiphase Brushless motor- Microprocessor based controller.

UNIT II PERMANENT MAGNET SYNCHROUNOUS MOTORS 9

Principle of operation – EMF and Torque equations - Phasor diagram - Power controllers -Torque speed characteristics – Digital controllers - Constructional features, operating principle and characteristics of synchronous reluctance motor.

UNIT III SWITCHED RELUCTANCE MOTORS 9

Constructional features -Principle of operation- Torque prediction- Speed -Torque Characteristics- Power controllers – Non-linear analysis -Control of SRM drive- Sensorless operation of SRM – **Computer Control** Applications.

UNIT IV STEPPER MOTORS 9

Constructional features -Principle of operation -Types – Torque predictions – Linear and Non-linear analysis – Characteristics – Drive circuits – Closed loop control -Applications.

UNIT V OTHER SPECIAL MACHINES 9

Principle of operation and characteristics of Hysteresis motor – AC series motors – Linear motor – Applications.

TOTAL: 45 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to:

- Describe the principle of operation of special electrical machines.
- Compare various aspects of special machines and their controllers
- Analyze the static and dynamic characteristics of special electrical machines.
- Explain both open loop and closed loop control of special electrical machines.
- Control the special electrical machines in open loop and closed loop.

REFERENCES:

1. T.J.E. Miller, "Brushless magnet and Reluctance motor drives", Claredon press, London, 1989.
2. R.Krishnan, "Switched Reluctance motor drives", CRC Press, 2001.
3. T.Kenjo, "Stepping motors and their microprocessor controls", Oxford University press, New Delhi, 2000.
4. T.Kenjo and S.Nagamori, "Permanent magnet and Brushless DC motors", Clarendon press, London, 1988.

5. R. Krishnan, “Electric motor drives”, Prentice Hall of India, 2002.
6. D.P.Kothari and I.J.Nagrath, “Electric machines”, Tata McGraw hill publishing company, New Delhi, Third Edition, 2004.
7. Irving L.Kosow, “Electric Machinery and Transformers”, Pearson Education, Second Edition, 2007.

15PPE302	DIGITAL CONTROLLERS IN POWER ELECTRONICS APPLICATION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To give knowledge on DSP & FPGA.
- To provide knowledge of control of electrical drives employing Digital controllers.
- To outline the overview of ADC.

UNIT I INTRODUCTION TO THE C2XX DSP 9

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

UNIT II INTERRUPTS AND I/O REGISTERS 9

Pin Multiplexing (MUX) and General Purpose I/O Overview, Multiplexing and General Purpose I/O Control Registers .Introduction to Interrupts, Interrupt Hierarchy, Interrupt Control Registers, Initializing and Servicing Interrupts in Software.

UNIT III OVERVIEW OF ADC 9

ADC Overview , Operation of the ADC in the DSP , Overview of the Event manager (EV) ,Event Manager Interrupts , General Purpose (GP) Timers , Compare Units, Capture Units And Quadrature Enclosed Pulse (QEP) Circuitry , General Event Manager Information.

UNIT IV INTRODUCTION OF FPGA 9

Introduction to Field Programmable Gate Arrays – CPLD Vs FPGA – Types of FPGA ,Xilinx XC3000 series , Configurable logic Blocks (CLB), Input/ Output Block (IOB) -Programmable Interconnect Point (PIP) – Xilinx 4000 series -overview of Spartan 3E and Virtex II pro FPGA boards- case study.

UNIT V APPLICATIONS 9

Controlled Rectifier with VHDL Programming, Switched Mode Power Converters, PWM Inverters, DC motor control, Induction Motor Control.

TOTAL: 45 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to:

- Explain the concepts digital controllers like DSP and FPGA.
- Experiment power converter circuits with VHDL Program.
- Write VHDL Program to control the power electronics circuits.
- Illustrate the overview of the ADC in the DSP.
- Control the power converters using DSP and FPGA.

REFERENCES:

1. Hamid A. Toliyat , Steven G. Campbell, “ DSP Based Electro Mechanical Motion Control ”, CRC Press, New York, 2004.
2. “XC 3000 series datasheets”, Xilinx, Inc, (version 3.1), USA, 1998.
3. “XC 4000 series datasheets”, Xilinx, Inc, (version 1.6), USA, 1999.
4. Wayne Wolf, “FPGA based system design”, Prentice hall, 2004.

15PPE303	PROJECT WORK (PHASE I)	L	T	P	C
		0	0	6	3

PROJECT DESCRIPTION

Every candidate shall be permitted to undertake a research based project work of his choice related to his / her discipline in consultation with the Head of the Department. The project shall be supervised by a faculty member of the department in which the candidate registered a course.

In case of a project work at Industrial / Research organization, the project work shall be jointly supervised by the faculty supervisor and an expert from the organization.

He / She shall be required to undergo three reviews in a semester to assess the progress of the project work. The project work shall be evaluated based on the project report submitted by the candidate and Viva-voce examination conducted by a committee consisting of an external examiner, internal examiner, and the supervisor of the candidate.

SEMESTER IV

SEMESTER IV

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	C
PRACTICAL						
1.	15PPE401	Project Work (Phase II)	0	0	30	15
Total			0	0	30	15
Total Number of Credits: 15						

SEMESTER-IV

		L	T	P	C
15PPE401	**PROJECT WORK (PHASE II)**	**0**	**0**	**30**	**15**

PROJECT DESCRIPTION

Every candidate shall be permitted to undertake a research based project work of his choice related to his / her discipline in consultation with the Head of the Department. The project shall be supervised by a faculty member of the department in which the candidate registered a course.

In case of a project work at Industrial / Research organization, the project work shall be jointly supervised by the faculty supervisor and an expert from the organization.

He / She shall be required to undergo three reviews in a semester to assess the progress of the project work. The project work shall be evaluated based on the project report submitted by the candidate and Viva-voce examination conducted by a committee consisting of an external examiner, internal examiner, and the supervisor of the candidate.

ELECTIVES

15PPE501	POWER ELECTRONICS FOR PV AND WIND ENERGY SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To explain different renewable energy resources, the principles involved in the conversion of PV & Wind energy to electrical energy.
- Give an idea on hybrid energy systems.
- To outline the power electronics for PV and Wind power systems.

UNIT I INTRODUCTION 9

Overview of Indian energy scenario - Energy sources and availability - Energy crisis - Need to develop new energy technologies – Solar energy availability in India – Wind survey in India – Emerging trends in electrical energy utility - Energy and environment.
Modeling of renewable energy sources-PV array, Wind Electric generators , Fuel cells etc in MATLAB/PSCAD Simulink environment .

UNIT II POWER ELECTRONICS FOR PHOTOVOLTAIC SYSTEMS 9

Solar cell fundamentals – Conversion of sunlight to electricity – Cell performance – Basics of photovoltaic -Types of PV power systems - **Design of PV Systems** -Standalone PV systems - Battery charging - PV charge controllers - Maximum Power Point Tracking (MPPT) - Inverters for standalone PV systems - Solar water pumping - Power conditioning unit for PV water pumping.

UNIT III HYBRID AND GRID CONNECTED PV SYSTEMS 9

PV Diesel hybrid systems - Control of PV - Diesel hybrid system - Grid connected PV systems - Inverters for grid connected applications - Inverter - Inverter types - Power control through PV inverters – System configuration – Grid inverter characteristics.

UNIT IV POWER ELECTRONICS FOR WIND POWER SYSTEM 9

Basics of wind power - Types of wind turbines - Types of wind generators - Types of wind power systems - Stand alone wind diesel hybrid systems - Grid connected wind energy systems.

UNIT V SYSTEM MANAGEMENT OF WIND ENERGY CONVERTER 9

Control circuitry – Microcontroller – Complex programmable logic device – Gate driver circuitry for wind energy applications- Modeling and simulation of hybrid renewable power system in MATLAB/PSCAD .Simulation and study of various power quality problems in hybrid /renewable energy power system.

TOTAL: 45 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to:

- Explain the stand alone and grid connected renewable energy.
- Choose suitable inverter for hybrid and grid connected PV System.
- Develop prototype model of PV and wind energy system.
- Develop maximum power point tracking algorithms.
- Control the power through PV inverters.

REFERENCES:

1. S.N.Bhadra, D. Kastha, & S. Banerjee ,"Wind Electricaal Systems", Oxford University Press,2009.
2. Erickson R, Angkrtitrakul S, Nasean O and Lujan G, " Novel power electronics systems for wind energy applications ", Final report, National Renewable Energy Laboratory, Colorado, US, Aug 24, 1999 – Nov 30, 2002.
3. Rai G. D, "Non conventional energy sources", Khanna publishers, 4th Edition, 2000.
4. Khan B.H, "Non Conventional Energy Resources", Tata Mc Graw Hill, 2nd Edition, 2006.
5. Manwell J.K, McGowan J.G, Rogers A.L, " Wind energy explained – Theory Design and applications ", John Wiley & Sons, 2nd Edition, 2009.
6. Rai. G.D, " Solar energy utilization", Khanna publishes, Delhi , 1993.

15PPE502 DIGITAL SIMULATION OF POWER ELECTRONIC SYSTEMS

L	T	P	C
3	0	0	3

OBJECTIVES:

- To outline the modelling of power electronics element.
- To familiarize the DC and AC machine modelling.
- To explain the concept of phase controlled DC motor drive.

UNIT I INTRODUCTION AND MODELLING OF POWER ELECTRONICS ELEMENT 9

Importance of simulation - Semiconductor device modeled as resistor - RL combination - RLC combination -Analog hybrid model for thyristor - Modeling of firing circuits for thyristor.

UNIT II SYSTEMATIC METHOD OF FORMULATION & SOLVING STATE EQUATION 9

Network topology - Incidence matrix - Fundamental cutest & loop matrices - Proper tree algorithm - Algorithm for the formulation of fundamental cutest matrix - Welsh Algorithm - Computer solution of state equation – Explicit & Implicit integration method.

UNIT III MACHINE MODELLING 9

DC machine modeling - Equivalent circuit & electromagnetic torque - Electromechanical modeling - State space modeling - AC machine modeling for three phase induction motors - Squirrel cage type.

UNIT IV PHASE CONTROLLED DC MOTOR DRIVES 9

Introduction to phase controlled converters - Single phase & three phase controlled converters - Control circuited - Control modeling - Steady state analysis of three phase converter controlled DC motor drive - **Simulation using Pspice Simulator** -Transfer function - Design of controllers.

UNIT V CASE STUDIES 9

Few case studies of DSP based controllers of induction motors & switched reluctance motors - Case studies using P Spice simulator.

TOTAL: 45 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to:

- Analyze the performance of electrical drives with phase controlled converter.
- Experiment the electrical machines using PSpice simulator.
- Explain the modeling of AC & DC machines.
- Design the controllers for DC motor drives.
- Control the electrical machines using DSP.

REFERENCES:

1. Rajagoplan V, “Computer aided analysis of power electronics systems”, Marcel Dekker Inc, USA, 1987.
2. Krishnan R, “Electric motor drives modeling analysis & control”, Prentice Hall of India Pvt Ltd, 2nd Edition, 2007.

3. Van Valkenburg M.E, “Network Analysis”, Prentice Hall of India Pvt Ltd, 3rd Edition, New Delhi, 1990.
4. “Simulink Reference Manual”, Math Works, USA .2000.
5. Ned Mohan,T.M Undeland and W.P Robbins, “Power Electronics: Converters, Application and Design”, John Wiley and sons Wiley ,India edition, 2006.

15PPE503 **HVDC SYSTEMS AND CONTROL**

L	T	P	C
3	0	0	3

OBJECTIVES:

- To impart knowledge on operation, modelling and control of HVDC link.
- To perform steady state analysis of AC/DC system.
- To expose various HVDC simulators.

UNIT I DC POWER TRANSMISSION TECHNOLOGY 9

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-**HVDC light System**.

UNIT II ANALYSIS OF HVDC CONVERTERS AND HVDC SYSTEM CONTROL 9

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 –Starting and stopping of DC link power control-Generation of harmonics and filtering - power control – Higher level controllers-Telecommunication requirements.

UNIT III MULTITERMINAL DC SYSTEM 9

Introduction – Potential application of MTDC systems – Types of MTDC systems -Control and protection of MTDC systems - Study of MTDC systems.

UNIT IV POWER FLOW ANALYSIS IN AC/DC SYSTEMS 9

Per unit system for DC Quantities - Modeling of DC links - Solution of DC load flow -Solution of AC-DC power flow - Case studies.

UNIT V SIMULATION OF HVDC SYSTEMS 9

Introduction – System simulation: Philosophy and tools – HVDC system simulation –Modeling of HVDC systems for digital dynamic simulation - Dynamic in traction between DC and AC systems.

TOTAL: 45 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to:

- Compare AC & DC transmission systems.
- Analyze the HVDC converters.
- Model the DC link for power flow analysis in AC/DC systems.
- Explain HVDC components on power system stability and various simulators.
- Model HVDC systems for digital dynamic simulation.

REFERENCES:

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

15PPE504	ELECTROMAGNETIC FIELD COMPUTATION AND MODELLING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To provide foundation in formulation and computation of Electromagnetic Fields using analytical and numerical methods.
- To introduce the concept of mathematical modeling and design of electrical apparatus.
- To impart in-depth knowledge on Finite Element Method in solving Electromagnetic field Problems.

UNIT I INTRODUCTION **9**

Review of basic field theory – Maxwell's equations – Constitutive relationships and Continuity equations – Laplace, Poisson and Helmholtz equation – principle of energy conversion – force /torque calculation.

UNIT II BASIC SOLUTION METHODS FOR FIELD EQUATIONS **9**

Limitations of the conventional design procedure need for the field analysis based design, problem definition, boundary conditions, solution by analytical methods-direct integration method – variable separable method – method of images, solution by numerical methods- Finite Difference Method.

UNIT III FORMULATION OF FINITE ELEMENT METHOD (FEM) **9**

Variational Formulation – Energy minimization – Discretisation – Shape functions -Stiffness matrix – 1D and 2D planar and axial symmetry problems.

UNIT IV COMPUTATION OF BASIC QUANTITIES USING FEM PACKAGES **9**

Basic quantities – Energy stored in Electric Field – Capacitance – Magnetic Field – Linked Flux – Inductance – Force – Torque – Skin effect – Resistance.

UNIT V DESIGN APPLICATIONS **9**

Insulators- Bushings – Cylindrical magnetic actuators – Transformers – Rotating machines.

TOTAL: 45 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to:

- Compute electric and magnetic field intensities.
- Choose adequate models and solution methods for specific problems.
- Compute basic electrical quantities using FEM packages.
- Design various machines insulators and bushings.
- Compare FDM and FEM for electromagnetic field computation.

REFERENCES:

1. Binns K. J, Lawrenson P.J, Trowbridge C.W, "The Analytical and Numerical Solution of Electric and Magnetic Fields", John Wiley & Sons, 1993.
2. Nathan Ida, Joao P.A. Bastos, " Electromagnetics and Calculation of Fields ", Springer- Verlage, 1992.
3. Nicola Biyanchi, "Electrical Machine Analysis using Finite Elements", Taylor and Francis Group, CRC Publishers, 2005.

4. Salon S.J, “Finite Element Analysis of Electrical Machines”, Kluwer Academic Publishers, London, 1995.
5. Silvester and Ferrari, “Finite Elements for Electrical Engineers”, Cambridge University press, 1983.
6. Matthew. N.O. Sadiku, “Elements of Electromagnetics”, Fourth Edition, Oxford University Press, First Indian Edition, 2007.

15PPE505	COMPUTER AIDED DESIGN OF POWER ELECTRONICS CIRCUITS	L	T	P	C
		3	0	0	3

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OBJECTIVES:

- To explain the various design aspects of computer aided power electronic circuits.
- To give an idea about advanced techniques in simulation.
- To outline the modeling of Power electronic devices.

UNIT I INTRODUCTION 9

Importance of simulation – General purpose circuit analysis – Methods of analysis of power electronic systems – Review of power electronic devices and circuits.

UNIT II ADVANCED TECHNIQUES IN SIMULATION 9

Analysis of power electronic systems in a sequential manner – coupled and decoupled systems – Various algorithms for computing steady state solution in power electronic systems – Future trends in computer simulation.

UNIT III MODELING OF POWER ELCTRONIC DEVICES 9

Introduction – AC sweep and DC sweep analysis – Transients and the time domain analysis – Fourier series and harmonic components – BJT, FET, and MOSFET and its model- Amplifiers and Oscillator – Non-linear devices.

UNIT IV SIMULATION OF CIRCUITS 9

Introduction – Schematic capture and libraries – Time domain analysis – System level integration and analysis – Monte Carlo analysis – Sensitivity/stress analysis – Fourier analysis.

UNIT V CASE STUDIES 9

Simulation of Converters, Choppers, Inverters, AC voltage controllers, and Cycloconverters feeding R, R-L, and R-L-E loads – computation of performance parameters: harmonics, power factor, angle of overlap.

TOTAL: 45 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to:

- Design circuits using pre-manufactured building blocks such as power supplies, semiconductors, and integrated circuits.
- Compute performance parameters of power converter circuits.
- Explain the modeling of power electronic devices.
- Analyze the performance of the Converters, Choppers, Inverters, AC voltage controllers, and Cycloconverters.
- Model the power electronic devices.

REFERENCES:

1. Rashid M, "Simulation of Power Electronic Circuits using PSPICE", PHI, 2006.
2. Rajagopalan V, "Computer Aided Analysis of Power Electronic systems", Marcell -Dekker Inc, 1987.
3. John Keown, " Microsim, Pspice and circuit analysis ", Prentice Hall Inc, 1998.

15PPE506	ELECTRIC VEHICLES AND POWER MANAGEMENT	L	T	P	C
		3	0	0	3

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OBJECTIVES:

- To familiarize Electric vehicles and Architecture of Electric Vehicle mechanics.
- To impart the knowledge on Energy Storage System.
- To outline the power training components.

UNIT I ELECTRIC VEHICLES AND VEHICLE MECHANICS 9

Electric Vehicles (EV), Hybrid Electric Vehicles (HEV), Engine ratings, Comparisons of EV with internal combustion Engine vehicles, Fundamentals of vehicle mechanics.

UNIT II ARCHITECTURE OF EV's AND POWER TRAIN COMPONENTS 9

Architecture of EV's and HEV's - Plug-n Hybrid Electric Vehicles (PHEV)- Power train components and sizing, Gears, Clutches, Transmission and Brakes.

UNIT III CONTROL OF DC AND AC DRIVES 9

DC/DC chopper based four quadrant operations of DC drives – Inverter based V/f Operation (motoring and braking) of induction motor drive system – Induction motor and permanent motor based vector control operation – Switched reluctance motor (SRM) drives.

UNIT IV BATTERY ENERGY STORAGE SYSTEM 9

Battery Basics, Different types, Battery Parameters, Battery modeling, Traction Batteries.

UNIT V ALTERNATIVE ENERGY STORAGE SYSTEMS 9

Fuel cell - Characteristics- Types - hydrogen Storage Systems and Fuel cell EV - Ultra capacitors.

TOTAL: 45 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to:

- Control DC and AC Drives using DC-DC Chopper.
- Summarize the Battery Energy and Alternative Energy Storage Systems.
- Compare Electric Vehicle with internal combustion Engine vehicles.
- Explain the Architecture of Ev's And Power Train Components.
- Compare the different types of battery for energy storage system.

REFERENCES:

1. Iqbal Husain, "Electric and Hybrid Vehicles Design Fundamentals", CRC Press, Taylor & Francis Group, 2011.
2. Ali Emadi, Mehrdad Ehsani, John M.Miller , "Vehicular Electric Power Systems", Special Indian Edition, Marcel dekker, Inc 2010.
3. Bimal K Bose, "Modern Power Electronics and AC Drives", Pearson Education, Asia, 2002.
4. Gopal K Dubey, "Power Semiconductor controlled Drives", Prentice Hall Inc, New Yersy, 1989.

15PPE507 POWER CONTROLLERS IN POWER SYSTEMS

L	T	P	C
3	0	0	3

OBJECTIVES:

- To explain comprehensive ideas on various aspects of FACTS Controllers**.**
- Give knowledge on emerging FACTS controllers.
- To analyze the interaction of different FACTS controller and perform control coordination.

UNIT I INTRODUCTION 9

Review of basics of power transmission networks-control of power flow in AC transmission line-Analysis of uncompensated AC Transmission line- Passive reactive power compensation: Effect of series and shunt compensation at the mid-point of the line on power transfer- Need for FACTS controllers- types of FACTS controllers-**Distributed FACTS**.

UNIT II STATIC VAR COMPENSATOR (SVC) AND APPLICATIONS 9

Thyristor Controlled Reactor (TCR) - Thyristor Switched Reactor (TSR) - Thyristor Switched Capacitor (TSC) - V-I Characteristics of Static Var Compensator (SVC)- Voltage control by SVC – Advantages of slope in dynamic characteristics – Influence of SVC on system voltage — Modelling of SVC for load flow analysis-Modelling of SVC for stability studies-Design of SVC to regulate the mid-point voltage of a SMIB system-Applications: Enhancement of transient stability – Steady state power transfer – Enhancement of power system damping – Prevention of voltage instability. Design of SVC to regulate the mid-point voltage of a SMIB system.

UNIT III THYRISTOR AND GTO THYRISTOR CONTROLLED SERIES CAPACITORS (TCSC and GCSC) 9

Concepts of Controlled Series Compensation – Operation of TCSC and GCSC- Analysis of TCSC-GCSC – Modelling of TCSC and GCSC for load flow studies- Modelling TCSC and GCSC for stability studies- Applications of TCSC and GCSC.

UNIT IV EMERGING FACTS CONTROLLERS 9

Static synchronous compensator(STATCOM)- Static synchronous series compensator(SSSC)-Operation of STATCOM and SSSC-Power flow control with STATCOM and SSSC- Modelling of STATCOM and SSSC for power flow and transient stability studies -operation of Unified and Interline power flow controllers(UPFC and IPFC)- Modelling of UPFC and IPFC for load flow and transient stability studies- Applications..

UNIT V CONTROLLERS AND THEIR COORDINATION 9

Controller interactions – SVC – SVC interaction- Co-ordination of multiple controllers using linear control techniques – Control coordination using genetic algorithms.

TOTAL: 45 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to:

- Model series and Shunt FACTS Controller for load flow Studies.
- Compare the performance of SVC, TCSC and STATCOM.
- Analyze the interaction of different FACTS Controller.
- Explain the operation and modeling of emerging FACTS Controllers.
- Model UPFC and IPFC for load flow and Transient Stability.

REFERENCES:

1. Mohan Mathur R, Rajiv K.Varma, " Thyristor – Based FACTS Controllers for Electrical Transmission Systems ", IEEE press and John Wiley & Sons, Inc., February 2002.

2. Narain G, Hingorani, “Understanding FACTS -Concepts and Technology of Flexible AC Transmission Systems”, Standard Publishers Distributors, New Delhi,2001.
3. Padiyar K.R, “FACTS Controllers in Power Transmission and Distribution”, New Age International (P) Limited, New Delhi, 2008.
4. John A.T, “Flexible A.C. Transmission Systems”, Institution of Electrical and Electronic Engineers (IEEE), 1999.
5. V. K.Sood, “HVDC and FACTS controllers- Applications of Static Converters in Power System”, Kluwer Academic Publishers, 2004.

15PPE508 **ELECTRIC POWER QUALITY**

L	T	P	C
3	0	0	3

OBJECTIVES:

- To explain the various power quality issues.
- To impart the knowledge of the conventional compensation techniques used for power factor correction and load voltage regulation.
- To familiarize the concept of power and power factor in single phase and three phase systems supplying non linear loads

UNIT I INTRODUCTION 9

Introduction – Characterization of Electric Power Quality: Transients, short duration and long duration voltage variations, Voltage imbalance, waveform distortion, Voltage fluctuations, Power frequency variation, Power acceptability curves. Symptoms of poor power quality. Power quality problems: poor load power factor, Non linear and unbalanced loads, DC offset in loads, Notching in load voltage, Disturbance in supply voltage – Power quality standards.

UNIT II ANALYSIS OF SINGLE PHASE AND THREE PHASE SYSTEM 9

Single phase linear and non linear loads – single phase sinusoidal, non sinusoidal source – supplying linear and nonlinear load - three phase Balance system - three phase unbalanced system - three phase unbalanced and distorted source supplying non linear loads - concept of pf – three phase three wire – three phase four wire system.

UNIT III CONVENTIONAL LOAD COMPENSATION METHODS 9

Principle of load compensation and voltage regulation - classical load balancing problem: open loop balancing - closed loop balancing, current balancing - harmonic reduction and voltage sag reduction - analysis of unbalance - instantaneous of real and reactive powers -Extraction of fundamental sequence component from measured.

UNIT IV LOAD COMPENSATION USING DSTATCOM 9

Compensating single – phase loads – Ideal three phase shunt compensator structure – generating reference currents using instantaneous PQ theory – Instantaneous symmetrical components theory – Generating reference currents when the source is unbalanced - Realization and control of STATCOM – DSTATCOM in Voltage control mode.

UNIT V SERIES COMPENSATION OF POWER DISTRIBUTION SYSTEM 9

Rectifier supported DVR – Dc Capacitor supported DVR – DVR Structure – voltage Restoration – **Series and Shunt Active Filter – PSCAD/EMTDC-Simulation of active filters**- Unified power quality conditioner.

TOTAL: 45 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to:

- Compute the power system parameters voltage, current, power, energy and power factor.
- Analyze Classical load balancing problem.
- Control STATCOM and DSTATCOM in voltage control mode.
- Explain the Concepts of power and power factor in single phase and three phase systems supplying non linear loads.
- Compare Load compensation and Series compensation.

REFERENCES:

1. Arindam Ghosh, "Power Quality Enhancement Using Custom Power Devices", Kluwer Academic Publishers, 2002.

2. Heydt G.T, “Electric Power Quality”, Stars in a Circle Publications, 2nd edition, 1994.
3. Roger C. Duggan, Mark F. McGranaghan Surya Santoso, Wayne Beauty H, “Electric Power system Quality” Tata McGraw Hill, Third edition, 2012.
4. Arrillga A.J, “Power system harmonics”. John Wiley & sons, 2003.

15PPE509 LINEAR AND NON LINEAR SYSTEM THEORY

L	T	P	C
3	0	0	3

OBJECTIVES:

- To outline the concepts of state variables design and stability analysis for a system.
- Give knowledge on stability.
- To introduce the concept of modal control.

UNIT I STATE VARIABLE REPRESENTATION 9

Introduction-Concept of State-State equation for Dynamic Systems -Time invariance and linearity-Non uniqueness of state model-State Diagrams - Physical System and State Assignment.

UNIT II SOLUTION OF STATE EQUATIONS 9

Existence and uniqueness of solutions to Continuous-time state equations-Solution of Nonlinear and Linear Time Varying State equations-Evaluation of matrix exponential-System modes- Role of Eigen values and Eigenvectors.

UNIT III CONTROLLABILITY AND OBSERVABILITY 9

Controllability and Observability- Stabilizability and Detectability-Test for Continuous time Systems-Time varying and Time invariant case-Output Controllability-Reducibility-System Realizations.

UNIT IV STABILTY 9

Introduction-Equilibrium Points-Stability in the sense of Lyapunov-BIBO Stability-Stability of LTI Systems-Equilibrium Stability of Nonlinear Continuous Time Autonomous Systems-The Direct Method of Lyapunov and the Linear Continuous-Time Autonomous Systems-Finding Lyapunov Functions for Nonlinear Continuous Time Autonomous Systems-Krasovskii and Variable- Gradiant Method.

UNIT V MODAL CONTROL 9

Introduction-Controllable and Observable Companion Forms-SISO and MIMO Systems-The Effect of State Feedback on Controllability and Observability-Pole Placement by State Feedback for both SISO and MIMO Systems-Full Order and Reduced Order Observers.

TOTAL: 45 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to:

- Analyze the stability and performance of Non-Linear systems.
- Describe the concept of MIMO systems.
- Compute the Stability of linear and Non-linear Systems.
- Use MATLAB and SIMULINK in the analysis, design, simulation, and real-time Implementation of closed-loop systems.
- Describe the controllability and observability of the system.

REFERENCES:

1. M. Gopal, “Modern Control Engineering”, Wiley, 2nd Edition, 1993.
2. John s. Bay, “Fundamentals of Linear State Space Systems”, McGraw-Hill, 1999.
3. Eroni- Umez and Eroni, “System dynamics & Control”, Thomson Brooks/ Cole, 2002.
4. K. Ogatta, “Modern Control Engineering”, Pearson Education Asia, 4th Edition. 2002.

5. Charles L. Phillips, Royce D. Harbor, “Feedback Control Systems”, Prentice Hall Inc, 4th Edition. , 1999.
6. D. Roy Choudhury, “Modern Control Systems”, New Age International, 2005.
7. John J. D’Azzo, C. H. Houpis and S. N. Sheldon, “Linear Control System Analysis and Design with MATLAB”, Taylor Francis, 2003.
8. Z. Bubnicki, “Modern Control Theory”, Springer, 2005.

15PPE510 SOLAR AND ENERGY STORAGE SYSTEM

L	T	P	C
3	0	0	3

OBJECTIVES:

- To discuss the characteristics of solar energy source and behavior of solar cells.
- To explain about design of standalone and grid connected PV system.
- To Review about different solar energy storage systems and application of PV system.

UNIT I INTRODUCTION **9**
Characteristics of sunlight - semiconductors and P-N junctions -behavior of solar cells - cell properties – PV cell interconnection.

UNIT II STAND ALONE PV SYSTEM **9**
Solar modules - storage systems - power conditioning and regulation - protection - stand alone PV 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

COURSE OUTCOMES:
After successful completion of this course the students will be able to:

- Describe the characteristics of sun radiation.
- Analyze the performance and efficiency of PV System.
- Design stand alone and Grid Connected PV System.
- Categorize the Energy Storage System.
- Apply solar power concept to direct-drive applications, water pumping and telecommunications.

REFERENCES:

1. Eduardo Lorenzo, "Solar Electricity: Engineering of Photovoltaic Systems" , Progensa, 1994.
2. Stuart R.Wenham, Martin A.Green, Muriel E. Watt and Richard Corkish, "Applied Photovoltaics", Earthscan, UK, 2007.
3. Frank S. Barnes and Jonah G. Levine, "Large Energy storage Systems Handbook", CRC Press, 2011.
4. McNeils, Frenkel and Desai , "Solar and Wind Energy Technologies", Wiley Eastern, 1990
5. Sukhatme S.P , "Solar Energy" ,Tata McGraw Hill, New Delhi,1987.

15PPE511 MICROCONTROLLER APPLICATIONS IN POWER CONVERTERS

L	T	P	C
3	0	0	3

OBJECTIVES

- To expose the students to the fundamentals of microcontroller based system design.
- To impart knowledge on PIC Microcontroller based system design.
- To introduce Microchip PIC 8 bit peripheral system Design.

UNIT I 8051 ARCHITECTURE **9**

Architecture – memory organization – addressing modes – instruction set – Timers - Interrupts -I/O ports, Interfacing I/O Devices – Serial Communication.

UNIT II 8051 PROGRAMMING **9**

Assembly language programming – Arithmetic Instructions – Logical Instructions –Single bit Instructions – Timer Counter Programming – Serial Communication Programming Interrupt Programming – RTOS for 8051 – RTOS Lite – FullRTOS – Task creation and run – LCD digital clock/thermometer using Full RTOS.

UNIT III PIC MICROCONTROLLER **9**

Architecture – memory organization – addressing modes – instruction set – PIC programming in Assembly& C -I/O port, Data Conversion, RAM & ROM Allocation, Timer programming.

UNIT IV PERIPHERAL OF PIC MICROCONTROLLER **9**

Timers – Interrupts, I/O ports- I2C bus-A/D converter-UART- CCP modules -ADC, DAC and Sensor Interfacing -Flash and EEPROM memories.

UNIT V SYSTEM DESIGN – CASE STUDY **9**

Introduction to MPLAB IDE and PICSTART plus-Device Programming using MPLAB and PICSTART plus - Generation of Gate signals for converters and Inverters - Motor Control - Controlling DC/ AC appliances – Measurement of frequency - Stand alone Data Acquisition System.

TOTAL : 45 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to:

- Explain PIC Microcontroller based system design.
- Generate the gate signals for converter and inverter using PIC Microcontroller.
- Control AC and DC drives.
- Interface microcontroller to power converter circuits.
- Write the program for LCD digital clock/thermometer using full RTOS.

REFERENCES:

1. Muhammad Ali Mazidi, Rolin D. Mckinlay, Danny Causey , “PIC Microcontroller and Embedded Systems using Assembly and C for PIC18”, Pearson Education 2008.
2. John Iovine, “PIC Microcontroller Project Book “, McGraw Hill 2000.
3. Myke Predko, “Programming and customizing the 8051 microcontroller”, Tata McGraw Hill 2001.
4. Muhammad Ali Mazidi, Janice G. Mazidi and Rolin D. McKinlay, “The 8051 Microcontroller and Embedded Systems” Prentice Hall, 2005.
5. Rajkamal, “Microcontrollers- Architecture, Programming, Interfacing & System Design”, 2^{nd} Edition , Pearson Publication,2012.
6. I Scott Mackenzie and Raphael C.W. Phan, “The Micro controller”, Pearson, Fourth edition, 2012.

15PPE512 **SWITCHED MODE POWER CONVERSION**

L	T	P	C
3	0	0	3

OBJECTIVES:

- To explain the concepts of switched mode power converters, resonant converters and rectifiers.
- Give knowledge on controller design and applications.
- To outline steady state and dynamic analysis of power converters.

UNIT I REACTIVE COMPONENTS 9

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

UNIT II SWITCHED MODE DC-DC CONVERTER 9

Principles of stepdown and stepup converters – Analysis and state space modeling of Buck, Boost, Buck- Boost and Cuk converters, flyback and Forward converters.

UNIT III STEADY STATE AND DYNAMIC ANALYSIS 9

Steady state analysis, stress and sizing of elements, control methods, duty ratio, current programmed, frequency programmed and sliding mode control, Dynamic analysis and frequency domain models.

UNIT IV RESONANT CONVERTERS AND RECTIFIERS 9

Classification of resonant converters, Basic resonant circuit concepts, Load resonant converters, Resonant switch converters, Zero voltage switching.
Design of feedback compensators, unity power factor rectifiers, resistor emulation principle and applications to rectifiers.

UNIT V CONTROLLER DESIGN AND APPLICATIONS 9

DC-DC converter controller- Controller Structure- PID Controller – I- PID Controller – II- PID Controller – III - Implementation of PID controller- Controller design principles- Pulse Width Modulator Active filters-, current filter, DC filters -classifications and principle of operation, Power line disturbances, Power conditioners, Un-interrupted Power supplies.

TOTAL: 45 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to :

- Design reactive elements in power electronic systems.
- Compare Isolated and Non-isolated Converter.
- Write the state space equation for power converters.
- Control the dc-dc converter using PID Controllers.
- Analyse the power converters.

REFERENCES:

1. "Switched Mode Power Conversion", Course Notes, CCE, IISc, 2004.
2. Issa Batarseh, "Power Electronic Circuits", John Wiley, 2004.
3. Philip T Krein, "Elements of Power Electronics", Oxford Press, 1998.
4. Ned Mohan, Undeland and Robbin "Power Electronics: converters, Application and design", John Wiley and sons. Inc, third edition, Newyork, 2007.

15PPE513	MODERN RECTIFIERS AND RESONANT CONVERTERS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To explain the dynamic analysis of DC to DC Converters.
- Give knowledge on Modern Rectifiers and resonant converters with their controls.
- To familiarize the control of techniques of resonant converters.

UNIT I POWER SYSTEM HARMONICS & LINE COMMUTATED RECTIFIERS 9

Average power-RMS value of a waveform-Power factor-AC line current harmonic standards IEC 1000-IEEE 519- The Single phase full wave rectifier-Continuous Conduction Mode-Discontinuous Conduction Mode-Behavior when C is large-Minimizing THD when C is small-Three phase rectifiers-Continuous Conduction Mode-Discontinuous Conduction Mode-Harmonic trap filters.

UNIT II PULSE WIDTH MODULATED RECTIFIERS 9

Properties of Ideal rectifiers-Realization of non ideal rectifier-Control of current waveform-Average current control-Current programmed Control- Hysteresis control- Nonlinear carrier control-Singlephase converter system incorporating ideal rectifiers-Modeling losses and efficiency in CCM high quality rectifiers-Boost rectifier Example -expression for controller duty cycle-expression for DC load current-solution for converter -Efficiency η.

UNIT III RESONANT CONVERTERS 9

Review on Parallel and Series Resonant Switches-Soft Switching- Zero Current Switching - Zero Voltage Switching -Classification of Quasi resonant switches-Zero Current Switching of Quasi Resonant Buck converter, Zero Current Switching of Quasi Resonant Boost converter, Zero Voltage Switching of Quasi Resonant Buck converter, Zero Voltage Switching of Quasi Resonant Boost converter: Steady State analysis. ZVS Three-level PWM -Converter.

UNIT IV DYNAMIC ANLYSIS OF SWITCHING CONVERTERS 9

Review of linear system analysis-State Space Averaging-Basic State Space Average Model-State Space Averaged model for an ideal Buck Converter, ideal Boost Converter, ideal Buck Boost Converter, for an ideal Cuk Converter- Continuous Conduction Mode-Discontinuous Conduction Mode.

UNIT V CONTROL OF RESONANT CONVERTERS 9

Pulse Width Modulation-Voltage Mode PWM Scheme-Current Mode PWM Scheme-Design of Controllers: PI Controller, Variable Structure Controller, Optimal Controller for the source current shaping of PWM rectifiers.

TOTAL: 45 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to :

- Control resonant converter Using PWM Scheme.
- Compute the performance parameters of rectifier and resonant converters.
- Analyze the switching converter using State Space Average Model.
- Compare ZVS and ZCS.
- Design the controllers for resonant converters.

REFERENCES:

1. Robert W. Erickson, Dragon Maksimovic, “Fundamentals of Power Electronics”, Springer science and Business media, Second Edition, 2001.
2. William Shepherd and Li zhang, “Power Converters Circuits”, Marcel Dekker,Inc, Third Edition, 2004.
3. Simon Ang and Alejandro Oliva, “Power- Switching Converters”, CRC Press, Taylor & Francis Group, Second Edition,2005.
4. Ned Mohan, Undeland and Robbins, “Power Electronics: converters, Application and design”, John Wiley and sons. Inc, third edition, Newyork, 2007.

15PPE514 **MICRO ELECTRO MECHANICAL SYSTEMS**

L	T	P	C
3	0	0	3

OBJECTIVES:

- To impart the knowledge of electrostatic, thermal , and piezo-electric sensing and actuation in various applications.
- To give exposure to different MEMS and NEMS devices
- To explain various sensors and actuators.

UNIT I MEMS:MICRO-FABRICATION, MATERIALS AND ELECTRO-MECHANICAL CONSEPTS 9

Overview of micro fabrication – Silicon and other material based fabrication processes -Concepts: Conductivity of semiconductors-Crystal planes and orientation-stress and strain flexural beam bending analysis-torsional deflections-Intrinsic stress- resonant frequency and quality factor.

UNIT II ELECTROSTATIC SENSORS AND ACTUATORS 9

Principle, material, design and fabrication of parallel plate capacitors as electrostatic sensors and actuators-Applications.

UNIT III THERMAL SENSING AND ACTUATORS 9

Principle, material, design and fabrication of thermal couples, thermal bimorph sensors, thermal resistor sensors and actuators-Applications.

UNIT IV PIEZOELECTRIC SENSING AND ACTUATORS 9

Piezoelectric effect-cantilever piezo electric actuator model-properties of piezoelectric materials-Applications.

UNIT V CASE STUDIES 9

Piezo resistive sensors, Magnetic actuation, Micro fluidics applications, Medical applications, Optical MEMS.-NEMS Devices.

TOTAL: 45 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to:

- Describe the micro fabrication, micro machined Transducers.
- Design Electrostatic, thermal and piezoelectric sensors and actuators.
- Characterize thermal sensors and actuators through design and modelling.
- Apply MEMS Technology into Micro fluidics and medical applications.
- Compare Thermal and Piezoelectric sensing.

REFERENCES:

1. Chang Liu, “Foundations of MEMS”, Pearson Education Inc, 2006.
2. Stephen D Senturia, “Microsystems Design”, Springer International, 2006.
3. Tai Ran Hsu, “MEMS and Micro systems Design and Manufacture”, Tata McGraw Hill, New Delhi, 2006.
4. Marc Madou , “ Fundamentals of Micro fabrication ” CRC press 1997.
5. Boston, “Micro machined Transducers Sourcebook”, WCB McGraw Hill, 1998.
6. Bao .M.H, “Micromechanical Transducers: Pressure sensors, Accelerometers and Gyroscopes”, Elsevier, Newyork, 2000.

15PPE515 WIND ENERGY CONVERSION SYSTEMS

L	T	P	C
3	0	0	3

OBJECTIVES:

- To discuss the power generated using different types of wind turbines.
- To explain the modeling of fixed and variable speed Wind turbine in WECS and about the impact of Grid connected WEC systems.
- To outline the grid integration issues.

UNIT I INTRODUCTION 9

Wind survey in India-Components of WECS-WECS schemes-Power obtained from wind-simple momentum theory- Power coefficient- Aerodynamics of Wind turbine.

UNIT II WIND TURBINES 9

Basics of wind power – Types of wind turbines – Types of wind generators – Types of wind power systems- Stand alone wind diesel hybrid systems-HAWT-VAWT-Power developed-Thrust-Efficiency-Rotor selection-Rotor design considerations-Tip speed ratio - No. of Blades-Blade profile-Power Regulation-yaw control-Pitch angle control-stall control-Schemes for maximum power extraction.

UNIT III FIXED SPEED SYSTEMS 9

Generating Systems- Constant speed constant frequency systems -Choice of Generators-Deciding factors-Synchronous Generator-Squirrel Cage Induction Generator- Model of Wind Speed- Model wind turbine rotor - Drive Train model-Generator model for Steady state and Transient stability analysis.

UNIT IV VARIABLE SPEED SYSTEMS 9

Need of variable speed systems-Power-wind speed characteristics-Variable speed constant frequency systems synchronous generator- DFIG- PMSG -Variable speed generators modeling - Variable speed variable frequency schemes.

UNIT V GRID CONNECTED SYSTEMS 9

Wind interconnection requirements, low-voltage ride through (LVRT), ramp rate limitations, andsupply of ancillary services for frequency and voltage control, current practices and industry trends wind interconnection impact on steady-state and dynamic performance of the power system including modeling issue.

TOTAL: 45 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to:

- Classify wind turbines, wind generators and wind power systems.
- Explain the modeling of fixed and variable speed Wind turbine in WECS.
- Describe the impact of grid connected WEC systems.
- Analyze the steady state and transient stability of wind systems.
- Manipulate Deciding factors for fixed speed system.

REFERENCES:

1. Freris.L. L, “Wind Energy conversion Systems”, Prentice Hall, 1990.
2. Ion Boldea, “Variable speed generators”, Taylor & Francis group, 2006.
3. Golding. E.W, “The generation of Electricity by wind power”, Redwood burn Ltd, Trowbridge, 1976.
4. Heir. S, “Grid Integration of WECS”, Wiley, 1998.

15PPE516	VLSI ARCHITECTURE AND DESIGN METHODOLOGIES	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To give an insight to the students about the significance of CMOS technology and fabrication process.
- To introduce the ASIC construction and design algorithms.
- To explain the Logic synthesis and simulation of digital system with Verilog HDL.

UNIT I CMOS DESIGN 9

Overview of digital VLSI design Methodologies- Logic design with CMOS-transmission gate circuits-Clocked CMOS-dynamic CMOS circuits, Bi-CMOS circuits- Layout diagram, Stick diagram-IC fabrications – Trends in IC technology.

UNIT II PROGRAMABLE LOGIC DEVICES 9

Programming Techniques-Anti fuse-SRAM-EPROM and EEPROM technology - Re-Programmable Devices Architecture- Function blocks, I/O blocks, Interconnects, Xilinx-XC9500,Cool Runner - XC-4000,XC5200, SPARTAN, Virtex - Altera MAX 7000-Flex 10KStratix.

UNIT III BASIC CONSTRUCTION, FLOOR PLANNING, PLACEMENT AND ROUTING 9

System partition - FPGA partitioning - Partitioning methods- floor planning - placement physical design flow - global routing - detailed routing - special routing- circuit extraction -DRC.

UNIT IV ANALOG VLSI DESIGN 9

Introduction to analog VLSI- Design of CMOS 2stage-3 stage Op-Amp -High Speed and High frequency op-amps-Super MOS-Analog primitive cells-realization of neural networks.

UNIT V LOGIC SYNTHESIS AND SIMULATION 9

Overview of digital design with Verilog HDL, hierarchical modelling concepts, modules and port definitions, gate level modelling, data flow modelling, behavioural modelling, task & functions, Verilog and logic synthesis-simulation-Design examples, Ripple carry Adders, Carry Look ahead adders, Multiplier, ALU, Shift Registers, Multiplexer, Comparator, Test Bench.

TOTAL: 45 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to:

- Explain the significance of CMOS technology and fabrication process.
- Design Digital logic circuits using Verilog HDL.
- Compare Digital and Analog VLSI Design.
- Control the electrical machines using FPGA.
- Write Verilog HDL program for adders, multipliers, shift registers etc.

REFERENCES:

1. Pucknell, “Basic VLSI Design”, Prentice Hall of India Publication, 1995.
2. M.J.S Smith, “Application Specific integrated circuits”, Addition Wesley Longman Inc., 1997.
3. Kamran Eshraghian,Douglas A.pucknell and Sholeh Eshraghian,” Essentials of VLSI circuits and system”, Prentice Hall India,2005.
4. Wayne Wolf, “Modern VLSI design”, Prentice Hall India,2006.

5. Mohamed Ismail ,Terri Fiez, “Analog VLSI Signal and information Processing”, McGraw Hill International Editions,1994.
6. Samir Palnitkar, “Veri Log HDL, A Design guide to Digital and Synthesis” 2^{nd} Ed, Pearson, 2005.
7. John P. Uyemera ,“Chip design for submicron VLSI CMOS layout and Simulation “, Cengage Learning India Edition”, 2011.
8. Zainalabedin Navabi, “ VHDL Analysis and Modeling of Digital Systems ”, McGraw Hill International Editions, Second Edition, 1998.
9. James M.Lee, “ Verilog Quick start ”, Kluwer Academic Publishers, Second Edition, 1999.

15PPE517 NANOMATERIALS AND ENERGY SYSTEMS

L	T	P	C
3	0	0	3

OBJECTIVES:

- To provide adequate knowledge about renewable energy technology..
- To expose the ideas about hydrogen and fuel cell technology.
- To provide adequate knowledge about super capacitors.

UNIT I RENEWABLE ENERGY TECHNOLOGY 9

Energy challenges, nano materials and nanostructures in energy harvesting, developments and implementation of nanotechnology based renewable energy technologies, solar cell structures: quantum well and quantum dot solar cells, photo-thermal cells for solar energy harvesting, thin film solar cells, CIGS solar cells, Dye sensitized solar cells. Organic PV cells, Concentrated solar power (CSP): Reflective materials, absorptive coatings, thermal storage.

UNIT II ENERGY STORAGE 9

Introduction, Battery types, Li-ion Battery, Battery components materials, cathodes, anodes, effect of nano size on energy storage and electrode materials performance. LIB for automobiles application, EV's, HEV, PHEV and power grid.

UNIT III SUPER CAPACITORS 9

Introduction, Electrochemical energy storage, Electrochemical capacitors, Electrochemical double layer capacitor, electrode materials super capacitors, Hybrid Nanostructures for super capacitors-metal oxides, conducting polymers, Electrolytes for super capacitors, types of electrolytes.

UNIT IV HYDROGEN STORAGE TECHNOLOGY 9

Hydrogen production methods, purification, hydrogen storage methods and materials: metal hydrides and metal organic framework materials, volumetric and gravimetric storage capacities, hydriding and dehydriding kinetics, high enthalphy formations and thermal management during hydriding reaction, multiple catalytic- degradation of sorption properties, automotive applications. Catalyst of hydrogen production, steam reforming & Water splitting. Nano porous membranes for hydrogen separation.

UNIT V FUEL CELL TECHNOLOGY 9

Fuel cell principles, types of fuel cells (Alkaline Electrolytie, phosphoric acid, Molten carbonate, solid oxide and direct methanol and proton exchange fuel cells), Principle and operation of proton exchange membrane (PEM) fuel cell, materials and fabrication methods for fuel cell technology, micro fuel cell power sources-biofuels.

TOTAL: 45 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to:

- Describe Nano materials and fuel cell materials.
- Describe the performance of energy storage and electrode materials.
- Categorize the energy storage system.
- Explain the principles of Energy Systems.
- Apply energy storage system to automobiles application and power grid.

REFERENCES:

1. D. Linden, “Handbook of Batteries and Fuel Cells”, Mcgraw-Hill, Noew York, 1984.
2. W. A. van Schalkwijk and B. Scrosati, “Advances in Lithium- Ion Batteries”, Kluwer Academic Publishers, Newyork, 2002.

3. Linden , D. and Reddy , T.B. (2002) “Handbook of Batteries” , 3rd edition , McGraw - Hill , New York
4. Crompton, T.R. (2000) “Battery Reference Book” , 3rd edition , Newnes , Oxford .
5. K. E. Aifantis and S. A. Hackney and R. Vasant Kumar, “High Energy Density Lithium Batteries”, Wiley-VCH Verlag, 2009.
6. University of Cambridge (2005) “DoIT PoMS Teaching and Learning Packages”, http://www.doitpoms.ac.uk/tlplib/batteries/ index.php (accessed 5 February 2010).

15PPE518 **NON LINEAR DYNAMICS FOR POWER ELECTRONIC CIRCUITS**

L	T	P	C
3	0	0	3

OBJECTIVES :

- To summarize the techniques for investigation on non linear behaviour of power electronic converters.
- To outline the non linear phenomena in DC to DC converters.
- To introduce the control techniques for control of non linear behaviour in power electronic Systems.

UNIT I BASICS OF NONLINEAR DYNAMICS **9**

Basics of Nonlinear Dynamics: System, state and state space model, Vector field- Modeling of Linear, nonlinear and Linearized systems, Attractors , chaos, Poincare map, Dynamics of Discrete time system, Lyapunov Exponent, Bifurcations, Bifurcations of smooth map, Bifurcations in piece wise smooth maps, border crossing and border collision bifurcation.

UNIT II TECHNIQUES FOR INVESTIGATION OF NONLINEAR PHENOMENA **9**

Techniques for experimental investigation, Techniques for numerical investigation, Computation of averages under chaos, Computations of spectral peaks, Computation of the bifurcation and analyzing stability.

UNIT III NONLINEAR PHENOMENA IN DC-DC CONVERTERS **9**

Border collision in the Current Mode controlled Boost Converter, Bifurcation and chaos in the Voltage controlled Buck Converter with latch, Bifurcation and chaos in the Voltage controlled Buck Converter without latch, Bifurcation and chaos in Cuk Converter. Nonlinear phenomenon in the inverter under tolerance band control.

UNIT IV NONLINEAR PHENOMENA IN DRIVES **9**

Nonlinear Phenomenon in Current controlled and voltage controlled DC Drives, Nonlinear Phenomenon in PMSM Drives.

UNIT V CONTROL OF CHAOS **9**

Hysteresis control, Sliding mode and switching surface control, OGY Method, Pyragas method, Time Delay control. Application of the techniques to the Power electronics circuit and drives.

TOTAL :45 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to:

- Analyse the non linear phenomena in AC and DC Drives.
- Estimate current ripple and torque ripple in inverter fed drives.
- Compare PWM techniques for different application.
- Compute switching and conduction losses of Converter.
- Analyse the non linear phenomena in DC to DC converters.

REFERENCES:

1. George C. Vargheese, S Banerjee, “Nonlinear Phenomena in Power Electronics”, IEEE Press Wiley, July 2001.
2. Steven H Strogatz, “Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry and Engineering”, Westview Press, Second Edition 2014.

3. C.K.Tse," Complex Behaviour of Switching Power Converters", CRC Press, 2003.
4. Mohan, Undeland and Robbins, "Power Electronics; Converters, Applications and Design", John Wiley and Sons, 1989.
5. Erickson R W, "Fundamentals of Power Electronics" Chapman and Hall, 1997.
6. Vithyathil J, "Power Electronics: Principles and Applications", 1995.

15PPE519	ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To provide fundamental knowledge on electromagnetic interference and electromagnetic compatibility.
- Give knowledge on EMC Radiation and Protective techniques.
- To expose the knowledge on testing techniques as per different Indian and international standards in EMI measurement.

UNIT I INTRODUCTION 9

Definitions of EMI/EMC -Sources of EMI- Intersystems and Intrasystem- Conducted and radiated interference- Characteristics - Designing for electromagnetic compatibility (EMC)- EMC regulation- typical noise path- EMI predictions and modeling, Cross talk - Methods of eliminating interferences.

UNIT II GROUNDING AND CABLING 9

Cabling- types of cables, mechanism of EMI emission / coupling in cables –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- -guard shields- isolation, neutralizing transformers, shield grounding at high frequencies, digital grounding- Earth measurement Methods.

UNIT III BALANCING, FILTERING AND SHIELDING 9

Power supply decoupling- decoupling filters-amplifier filtering –high frequency filtering- EMI filters characteristics of LPF, HPF, BPF, BEF and power line filter design -Choice of capacitors, inductors, transformers and resistors, EMC design components -shielding – near and far fields- shielding effectiveness- absorption and reflection loss- magnetic materials as a shield, shield discontinuities, slots and holes, seams and joints, conductive gaskets-windows and coatings grounding of shields.

UNIT IV EMI IN ELEMENTS AND CIRCUITS 9

Electromagnetic emissions, noise from relays and switches, non-linearities in circuits, passive inter modulation, transients in power supply lines, EMI from power electronic equipment, EMI as combination of radiation and conduction.

UNIT V ELECTROSTATIC DISCHARGE, STANDARDS AND TESTING TECHNIQUES 9

Static Generation- human body model- static discharges- ESD versus EMC, ESD protection in equipments- standards – FCC requirements – EMI measurements – Open area test site measurements and precautions- Radiated and conducted interference measurements, Control requirements and testing methods.

TOTAL: 45 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to:

- Explain the electromagnetic compatibility principles and techniques with reference to conducted and radiated interference.
- Compare EMI and EMC from electronic equipment.
- Analyze balancing, filtering and shielding.
- Design EMC components.
- Measure radiated and conducted interferences.

REFERENCES:

1 V.P. Kodali, “Engineering Electromagnetic Compatibility”, S. Chand, 1996.

2 Henry W.Ott, “ Noise reduction techniques in electronic systems”, John Wiley & Sons, 1989.

3 Bernhard Keiser, “Principles of Electro-magnetic Compatibility”, Artech House, Inc. (685 canton street, Norwood, MA 020062 USA) 1987.

4 Bridges, J.E Milleta J. and Ricketts.L.W., “EMP Radiation and Protective techniques”, John Wiley and sons, USA 1976.

5 Weston DavidA.,“ Electromagnetic Compatibility: Principles and Applications”, Marcel Dekker, Newyork, 1991.

15PPE520	SMART GRID	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To explain Smart Grid technologies, different smart meters and advanced metering infrastructure.
- To summarize the power quality issues in smart grid.
- To familiarize the high performance computing for smart grid applications.

UNIT I INTRODUCTION TO SMART GRID 9

Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, Concept of Resilient & Self Healing Grid, Present development & International policies in Smart Grid, Diverse perspectives from experts and global Smart Grid initiatives.

UNIT II SMART GRID TECHNOLOGIES 9

Technology Drivers, Smart energy resources, Smart substations, Substation Automation, Feeder Automation ,Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control, Distribution systems: DMS, Volt/VAr control, Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV).

UNIT III SMART METERS AND ADVANCED METERING INFRASTRUCTURE 9

Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits, AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit(PMU), Intelligent Electronic Devices(IED) & their application for monitoring & protection.

UNIT IV POWER QUALITY MANAGEMENT IN SMART GRID 9

Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.

UNIT V HIGH PERFORMANCE COMPUTING FOR SMART GRID APPLICATIONS 9

Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), IP based Protocols, Basics of Web Service and CLOUD Computing to make Smart Grids smarter, Cyber Security for Smart Grid.

TOTAL: 45 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to:

- Differentiate conventional & Smart Grid.
- Summarize the main issues with successful integration of smart grid technologies.
- Identify successful applications and operations of HVDC and FACTS.
- Evaluate power quality and EMC issues in smart grid.
- Explain about high performance computing for smart grid applications.

REFERENCES:

1 Stuart Borlase, “ Smart Grids :Infrastructure, Technology and Solutions ”, CRC Press, 2012.

2 Janaka Ekanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, “Smart Grid: Technology and Applications”, Wiley publication, First Edition, 2012.

3 Vehbi C,Güngör, Dilan Sahin, Taskin Kocak, Salih Ergüt, Concettina Buccella, Carlo Cecati, and Gerhard P.Hancke, "Smart Grid Technologies: Communication Technologies and Standards ", IEEE Transactions on Industrial Informatics, Vol. 7, No. 4, November 2011.

4 Xi Fang, Satyajayant Misra, Guoliang Xue and Dejun Yang, "Smart Grid – The New and Improved Power Grid: A Survey", IEEE communications surveys and tutorials, Transaction Vol.14, No. 4, Fourth Quarter, 2012.

15PPE521 DISTRIBUTED GENERATION AND MICRO GRID

L	T	P	C
3	0	0	3

OBJECTIVES:

- To illustrate the concept of distributed generation.
- To outline the impact of grid integration.
- To explain the concept of Microgrid and its operation & control.

UNIT I INTRODUCTION 9

Conventional power generation: advantages and disadvantages, Energy crises, Non-conventional energy (NCE) resources: review of Solar PV, Wind Energy systems, Fuel Cells, micro-turbines, biomass, and tidal sources.

UNIT II DISTRIBUTED GENERATIONS (DG) 9

Concept of distributed generations, topologies, selection of sources, regulatory standards/ framework, Standards for interconnecting Distributed resources to electric power systems: IEEE 1547. DG installation classes, security issues in DG implementations. Energy storage elements: Batteries, ultra-capacitors, flywheels. Captive power plants.

UNIT III IMPACT OF GRID INTEGRATION 9

Requirements for grid interconnection, limits on operational parameters,: voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues. Impact of grid integration with NCE sources on existing power system: reliability, stability and power quality issues.

UNIT IV INTRODUCTION OF MICROGRID 9

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 Electronics interfaces in DC and AC microgrids.

UNIT V OPERATION AND CONTROL OF MICROGRID 9

Modes of operation and control of microgrid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques, microgrid communication infrastructure, Power quality issues in microgrids, regulatory standards, Microgrid economics, Introduction to smart microgrids.

TOTAL: 45 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to:

- Identify the limits on operational parameters of Micro Grid.
- Compare AC and DC Micro Grid.
- Control the active and reactive power of Micro grid.
- Analyze the impact of grid integration.
- Describe the requirements for grid interconnection.

REFERENCES:

1 Amirnaser Yezdani, Reza Iravani, “Voltage Sourced Converters in Power Systems: Modeling, Control and Applications”, IEEE John Wiley Publications, 2010.

2 Dorin O. Neacsu, “Power -Switching Converters: Medium and High Power”, CRC Press, 2006.

3 Chetan Singh Solanki, “Solar Photo Voltaic”, PHI learning Pvt. Ltd., New Delhi, 2009.

4 Manwell J. F, McGowan J.G , Rogers A.L , " Wind Energy Explained: Theory, Design and Applications", Wiley Publications,2002.
5 Hall D.D, Grover R. P, "Biomass Regenerable Energy", John Wiley, New York, 1987.

15PPE522 TRANSIENT OVER VOLTAGES IN POWER SYSTEMS

L	T	P	C
3	0	0	3

OBJECTIVES:

- To introduce the concept of transient overvoltages in power system.
- To explain the lightning overvoltages switching and the insulation Co-ordination.
- To illustrate the computation of power system transients.

UNIT I LIGHTNING OVERVOLTAGES 9

Mechanism and parameters of lightning flash, protective shadow, striking distance, electro geometric model for lightning strike, Grounding for protection against lightning – Steadystate and dynamic tower-footing resistance, substation grounding Grid, Direct lightning strokes to overhead lines, without and with shield Wires.

UNIT II SWITCHING AND TEMPORARY OVERVOLTAGES 9

Switching transients - concept - phenomenon - system performance under switching surges, Temporary overvoltages – load rejection – line faults – ferro resonance, VFTO.

UNIT III TRAVELLING WAVES ON TRANSMISSION LINE 9

Circuits and distributed constants, wave equation, reflection and refraction – behaviour of travelling waves at the line terminations - Lattice Diagrams - attenuation and distortion - multi conductor system and multivelocity waves.

UNIT IV INSULATION CO-ORDINATION 9

Classification of overvoltages and insulations for insulation co-ordination – Characteristics of protective devices, applications, location of arresters - insulation co-ordination in AIS and GIS.

UNIT V COMPUTATION OF POWER SYSTEM TRANSIENTS 9

Modelling of power apparatus for transient studies – principles of digital computation – transmission lines, cables, transformer and rotating machines – Electromagnetic Transient program – case studies: line with short and open end, line terminated with R, L, C, transformer, typical power system case study: simulation of possible overvoltages in a high voltage substation.

TOTAL: 45 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to:

- Discuss the transient overvoltages in of power system.
- Compute transient parameter values for transformers, generators and transmission lines.
- Describe the behavior of travelling waves on transmission lines.
- Explain the insulations and Insulation coordination.
- Compute the power system transients using EMTP.

REFERENCES:

1 Pritindra Chowdhari, “Electromagnetic transients in Power System”, John Wiley and Sons Inc., Second Edition, 2009.

2 Allan Greenwood, “Electrical Transients in Power System”, Wiley & Sons Inc. New York, 2012.

3 Klaus Ragaller, “Surges in High Voltage Networks”, Plenum Press, New York, 1980.

4 Rakosh Das Begamudre, “Extra High Voltage AC Transmission Engineering”, (Second edition) New age International (P) Ltd., New Delhi, 2006.

5 Naidu M S and Kamaraju V, “High Voltage Engineering”, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004.
6 IEEE Guide for safety in AC substation grounding IEEE Standard 80-2000.
7 Working Group 33/13-09 (1988), ‘Very fast transient phenomena associated with Gas Insulated System’, CIGRE, 33-13, pp. 1-20.

15PPE523	RESTRUCTURED POWER SYSTEM	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To impart knowledge on fundamental concepts of power system restructuring.
- To outline the concepts of congestion management, transmission pricing and ancillary services in restructuring environment.
- To review on reforms in Indian power sector.

UNIT I INTRODUCTION TO RESTRUCTURING OF POWER INDUSTRY 9

Introduction: Deregulation of power industry, Restructuring process, Issues involved in deregulation, Deregulation of various power systems - Fundamentals of Economics: Consumer behavior, Supplier behavior, Market equilibrium, Short and long run costs, Various costs of production – Market models: Market models based on Contractual arrangements, Comparison of various market models, Electricity vis – a – vis other commodities, Market architecture, Case study.

UNIT II TRANSMISSION CONGESTION MANAGEMENT 9

Introduction: Definition of Congestion, reasons for transfer capability limitation, Importance of congestion management, Features of congestion management - Classification of congestion management methods - Calculation of ATC - Non - market methods - Market methods - Nodal pricing - Inter zonal and Intra zonal congestion management - Price area congestion management - Capacity alleviation method-Calculation of static and dynamic ATC.

UNIT III LOCATIONAL MARGINAL PRICES AND FINANCIAL TRANSMISSION RIGHTS 9

Mathematical preliminaries: - Locational marginal pricing- Lossless DCOPF model for LMP calculation - Loss compensated DCOPF model for LMP calculation - ACOPF model for LMP calculation - Financial Transmission rights - Risk hedging functionality - Simultaneous feasibility test and revenue adequency - FTR issuance process: FTR auction, FTR allocation - Treatment of revenue shortfall - Secondary trading of FTRs - Flow gate rights - FTR and market power - FTR and merchant transmission investment.

UNIT IV ANCILLARY SERVICE MANAGEMENT AND PRICING OF TRANSMISSION NETWORK 9

Introduction of ancillary services - Types of Ancillary services - Classification of Ancillary services - Load generation balancing related services - Voltage control and reactive power support devices - Black start capability service - How to obtain ancillary service -Co-optimization of energy and reserve services - International comparison

Transmission pricing – Principles – Classification – Rolled in transmission pricing methods – Marginal transmission pricing paradigm - Composite pricing paradigm - Merits and demerits of different paradigm.

UNIT V REFORMS IN INDIAN POWER SECTOR 9

Introduction - Framework of Indian power sector - Reform initiatives - Availability based tariff - Electricity act 2003 - Open access issues - Power exchange - Reforms in the near future.

TOTAL: 45 periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to:

- Explain the concepts of restructuring of power industry.
- Discuss the Transmission congestion management.
- Classify ancillary service management and pricing of Transmission network.
- Compute the system marginal price.

- Outline the reforms in Indian power sector.

REFERENCES:

1 Mohammad Shahidehpour, Muwaffaq Alomoush, Marcel Dekker, “Restructured Electrical Power Systems: Operation, Trading and Volatility ”, Marcel Dekker Publication, 2001.

2 Kankar Bhattacharya, Jaap E, Daadler, Math H.J. Boolen, “Operation of Restructured Power Systems”, Kluwer Academic Publication, 2001.

3 Sally Hunt, “Making competition work in electricity”, John Willey and Sons Inc, 2002.

4 Steven Soft, “Power System Economics: Designing Markets for Electricity”, John Wiley & Sons, 2002.

5 Lai L. L,” Power System Restructuring and Deregulation: Trading, Performance and Information Technology”, Willey & Sons, 2002.

15PPE524	OPTIMIZATION TECHNIQUES IN POWER ELECTRONICS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To provide detailed understanding of Optimization Techniques Applied to extract maximum power from photo voltaic systems and Wind Electric conversion System.
- To acquire an in-depth knowledge on application of Optimization Techniques to Power Electronics.
- To impart knowledge on various Optimization Techniques Applied to Power Electronics engineering.

UNIT I INTRODUCTION 9

Introduction to fitness evaluation, Definition-classification of optimization problems, unconstrained and constrained optimization, optimality conditions, classical optimization techniques (Linear and nonlinear programming, Quadratic programming, Mixed integer programming)-. Encoding and decoding functions, Introduction to constraint-handling techniques.

UNIT II EVOLUTIONARY COMPUTATION TECHNIQUES 9

Fundamentals of evolutionary algorithms-principle of simple Genetic Algorithm- Evolutionary Strategy and Evolutionary Programming- Direction based Search-Genetic operators-selection, crossover and mutation- issues in GA implementation.

UNIT III ADVANCED OPTIMIZATION METHODS 9

Fundamental principle, velocity updating, advanced operators, hybrid approaches implementation issues (Hybrid of GA and PSO, Hybrid of EP and PSO); Simplifying Particle Swarm Optimization, Optimizer Simplification & Meta-Optimization. Fundamental principle, Classification of Differential Evolution techniques, Bacterial foraging, Bees colony algorithm, Concept of MPPT.

UNIT IV MULTI OBJECTIVE OPTIMIZATION 9

Concept of pareto optimality-Conventional approaches for MOOP-Multi objective GA-Fitness assignment-Sharing function-NSGA-II, -Multi objective PSO (Dynamic neighbourhood PSO, Vector evaluated PSO)

UNIT V OPTIMISATION TECHNIQUE APPLIED TO POWER ELECTRONICS APPLICATIONS 9

Passive filter design using genetic algorithm, harmonics elimination in inverters, Tuning of controllers, PV systems-Wind Electric conversion System - GA, PSO, DE, Optimized fuzzy logic control for the Maximum Power Point Tracking (MPPT).

TOTAL: 45 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to:

- Apply optimization techniques power electronics applications.
- Design passive filter using GA.
- Classify different optimization and evaluation techniques.
- Implement GA & PSO to power electronics applications.
- Explain the optimization methods.

REFERENCES:

1. Singiresu S.Rao,"Engineering Optimization - Theory and Practice" by John Wiley & Sons, Inc., New Jersey, 2009.
2. Kothari D.P. and Dillon J.S., "Power system optimization", PHI, 2004.
3. Thomas Back, David B Fogel and Zbigniew Michalewicz, "Evolutionary Computation 2 Advanced Algorithms and Operators" Institute of Physics Publishing, UK, 2000.

4. Kalyanmoy Deb, “Muti-objective Optimization using Evolutionary Algorithms”, John Wiley & Sons 2001.
5. Kennedy J, “Swarm Intelligence”, Morgan Kaufmann Publishers, Eberhart R 2001.
6. Kaddah, S.S, “Genetic algorithm based optimal operation for photovoltaic systems under different fault criteria”, Proceedings of IEEE Power Systems Conference, 2006.
7. F.Jafari, A.Dastfan, “Optimization of Single-phase PWM Rectifier Performance by Using the Genetic Algorithm”, International Conference on Renewable Energies and Power Quality (ICREPQ’10) Granada (Spain), 23rd to 25th March, 2010.

15PPE525	ENERGY MANAGEMENT AND AUDITING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To emphasize the energy management on various electrical equipments and metering.
- To illustrate the concept of lighting systems and cogeneration.
- To outline concepts behind economic analysis and Load management.

UNIT I INTRODUCTION 9

Need for energy management - energy basics- designing and starting an energy management program - energy accounting -energy monitoring, targeting and reporting- energy audit process.

UNIT II ENERGY COST AND LOAD MANAGEMENT 9

Important concepts in an economic analysis - Economic models-Time value of money-Utility rate structures- cost of electricity-Loss evaluation. Load management: Demand control techniques-Utility monitoring and control system-HVAC and energy management-Economic justification.

UNIT III ENERGY MANAGEMENT FOR MOTORS, SYSTEMS, AND ELECTRICALEQUIPMENT 9

Systems and equipment- Electric motors-Transformers and reactors-Capacitors and synchronous machines. **Refrigeration & Air conditioning-Heat load estimation**

UNIT IV METERING FOR ENERGY MANAGEMENT 9

Relationships between parameters-Units of measure-Typical cost factors- Utility meters – Timing of meter disc for kilowatt measurement - Demand meters - Paralleling of current transformers - Instrument transformer burdens-Multitasking solid-state meters - Metering location vs. requirements- Metering techniques and practical examples.

UNIT V LIGHTING SYSTEMS & COGENERATION 9

Concept of lighting systems - The task and the working space -Light sources - Ballasts - Luminaries - Lighting controls-Optimizing lighting energy - Power factor and effect of harmonics on power quality - Cost analysis techniques-Lighting and energy standards Cogeneration: Forms of cogeneration - feasibility of cogeneration- Electrical interconnection.

TOTAL: 45 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to:

- Analyze energy management for motors, systems, and electrical equipments.
- Explain the concept of lighting systems & cogeneration.
- Analyze the effect of harmonics on power quality and cost analysis techniques.
- Measure the energy parameters.
- Relate Energy management parameters.

REFERENCES:

1. Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, “Guide to Energy Management”, Fifth Edition, The Fairmont Press, Inc., 2006.
2. Eastop T.D & Croft D.R, “Energy Efficiency for Engineers and Technologists”, Logman Scientific & Technical, ISBN-0-582-03184, 1990.

3. Reay D.A, Industrial Energy Conservation, 1st edition, Pergamon Press, 1977.
4. "IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities", IEEE Industry Application Society , IEEE std 739-1995.
5. Amit K. Tyagi, " Handbook on Energy Audits and Management" , TERI, 2003

15PPE526	ANALYSIS AND MODELING OF DIGITAL SYSTEM USING VHDL	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To impart the knowledge of VHDL fundamentals, data types and basic modeling constructs.
- To provide students with a understanding of circuit and System Design with VHDL.
- To explain ADTS AND FILES.

UNIT I VHDL FUNDAMENTALS 9

Fundamental Concepts - Modeling Digital Systems - Domains and Levels of Modeling - Modeling Languages - VHDL Modeling concepts - Scalar Data Types and Operations - Constants and variables - Scalar Types - Type Classification - Attributes and Scalar types - Expressions and operators – Sequential Statements – If statements – Case statements – Null Statements – Loop statements – Assertion and Report statements.

UNIT II COMPOSITE DATA TYPES AND BASIC MODELING CONSTRUCTS 9

Arrays – Unconstrained Array types – Array Operations and Referencing – Records – Basic Modeling Constructs - Entity Declarations - Architecture Bodies - Behavioral Descriptions - Structural Descriptions - Design Processing. Case Study: A pipelined Multiplier Accumulator.

UNIT III SUBPROGRAMS AND PACKAGES 9

Procedures - Procedure Parameters - Concurrent Procedure Call Statements - Functions - Overloading - Visibility of Declarations - Packages and Use Clauses - Package declarations - Package bodies - Use Clauses - The predefined - Aliases - Aliases for data objects - Aliases for Non-Data Items. Case Study: A Bit-Vector Arithmetic Package.

UNIT IV SIGNALS, COMPONENTS AND CONFIGURATIONS 9

Basic Resolved signals – IEEE Std_Logic_1164 Resolved subtypes – Resolved signal parameters – Generic Constants - Parameterizing behavior - Parameterizing structure - Components and Configurations - Components - Configuring component Instances - Configuration Specification - Generate Statements - Generating iterative structure - Conditionally generating structures - Configuration of generate Statements. Case Study: The DLX Computer System.

UNIT V ADTS AND FILES 9

Access Types - Linked Data structures - Abstract Data Types using Packages - Files and Input/ Output – Files – The Package Textio – VHDL - Case Study: Queuing Networks.

TOTAL: 45 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to:

- Explain VHDL and programmable logic devices based on Xilinx foundation tools.
- Analyze the modeling using VHDL can be effectively integrated into a logic design.
- Discuss about ADTS and files.
- Design a digital system based on VHDL including modeling, simulation, and synthesis.
- Model digital system using VHDL.

REFERENCES:

1. Peter J.Ashenden, " The Designer's Guide to VHDL ", Morgan Kaufmann Publishers, Second

Edition, San Francisco, May 2001

2. Zainalabedin Navabi, " VHDL Analysis and Modeling of Digital Systems ", McGraw Hill International Editions, Second Edition, 1998.
3. James M.Lee, " Verilog Quick start ", Kluwer Academic Publishers, Second Edition, 1999.

15PPE527	DESIGN AND CONTROL OF SWITCHED RELUCTANCE MACHINE FOR AUTOMOTIVE APPLICATIONS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To provide conceptual knowledge in designing and control of SRM.
- To explain the converters for switched reluctance machine Drives.
- To outline the FEA of switched reluctance machine Motors.

UNIT I DESIGN OF SWITCHED RELUCTANCE MACHINE 9

Introduction - Output equation - Selection of Dimensions - Design verification - operational limit - number of phases - number of poles - ratio of pole arc to pole pitch - selection of pole arcs - effect of air gap measurement of inductance – calculation of torque.

UNIT II CONVERTERS FOR SWITCHED RELUCTANCE MACHINE DRIVES 9

Converter configurations – asymmetric bridge converter – single switch per phase converter - (q+1) switch and diode configurations – C-dump converter – design procedure – two – stage power converter.

UNIT III CONTROL OF SWITCHED RELUCTANCE MACHINE DRIVES 9

Introduction – control principle – closed – loop speed controlled SRM drive – design of current controllers - rotor position measurement and estimation methods - sensor less rotor position estimation - observer - based rotor estimation - intelligent - control - based estimation.

UNIT IV FEA OF SWITCHED RELUCTANCE MACHINE MOTORS 9

Introduction - assumptions - derivation of partial differential equations - boundary conditions - thermal analysis of SRM – modal analysis of SRM.

UNIT V NOISE AND VIBRATION OF SWITCHED RELUCTANCE MACHINE 9

Introduction - numerical models of SRM stator modal analysis - FE results of stator modal analysis - design selection of low vibration SRM 's - effects of smooth frame on resonant frequencies - modeling and parameter identification of SRM – SR drive automotive applications.

TOTAL: 45 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to:

- Design a dynamic model for switched reluctance machine.
- Analyze of optimal control strategies for switched reluctance motors.
- Explain the concept of stator modal analysis.
- Experiment the switched reluctance machine drives with speed and current controller.
- Select suitable design parameters for SRM.

REFERENCES:

1. Ali Emadi, “Hand book of Automotive Power Electronics and Motor Drives”, CRC press, 2005.
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15PPE528	RECENT TECHNIQUES FOR RELIABLE DISTRIBUTION SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To provide conceptual knowledge in reliable distribution systems.
- To explain harmonic and flicker analysis.
- To outline the electricity pricing - volatility, risk and forecasting.

UNIT I ADAPTIVE COTROL AND ADAPTATION TECHNIQUES 9

Introduction - Uses - Auto tuning - Self Tuning Regulators (STR) - Model Reference Adaptive Control MRAC) - Types of STR and MRAC - Different approaches to self-tuning regulators - Stochastic Adaptive control – Gain Scheduling.

UNIT II HARMONIC ANALYSIS 9

Harmonic Sources-System Response to Harmonics-System Model for Computer-Aided Analysis-Acceptance Criteria-Harmonic Filters-Harmonic Evaluation-Case Study-Summary and Conclusions.

UNIT III FLICKER ANALYSIS 9

Sources of Flicker-Flicker Analysis-Flicker Criteria-Data for Flicker analysis- Case Study-Arc Furnace Load-Minimizing the Flicker Effects-Summary.

UNIT IV ELECTRICITY PRICING - VOLATILITY, RISK AND FORECASTING 9

Electricity Price Volatility: Factors in Volatility, Measuring Volatility - Electricity Price Indexes: Case Study for Volatility of Prices in California, Basis Risk - Challenges to Electricity Pricing: Pricing Models, Reliable Forward Curves - Construction of Forward Price Curves: Time frame for Price Curves, Types of Forward Price Curves – Short-term Price Forecasting: Factors Impacting Electricity Price, Forecasting Methods, Analyzing Forecasting Errors, Practical Data Study.

UNIT V SUPPORT VECTOR MACHINES 9

Introduction - An overview - Classification - Pattern Classification - Linear Support Vector Machines - Non Linear Support Vector Machines.

TOTAL: 45 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to:

- Explain the fundamental principles of adaptive control techniques.
- Summarize harmonic analysis of distributed Systems.
- Apply flicker analysis to some case studies.
- Describe challenges in electricity pricing.
- Classify support vector machines.

REFERENCES:

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15PPE529 **APPLICATION OF INTELLIGENT CONTROLLERS FOR POWER QUALITY IMPROVEMENT**

L	T	P	C
3	0	0	3

OBJECTIVES:

- To provide conceptual knowledge in application of intelligent controllers for power quality improvement.
- To explain Modeling and simulation techniques for harmonic filters.
- To outline the NEURO-FUZZY controller for STATCOM**.**

UNIT I INTRODUCTION 9

Control of Power Converters: Single Phase Inverter-Three Phase Inverter Switching of Power Converters-High Voltage Inverters - Inverters for High Power and Voltage: Multi-Step / Multilevel / Chain Inverter. Open - Loop Voltage Control, Closed- Loop Switching Control, Second and Higher Order Systems. Classification of Electrical disturbances affects in power Quality.

UNIT II INTRODUCTION TO CUSTOM POWER DEVICES 9

DSTATCOM Structure, DSTATCOM in Voltage control mode: State/ Output feedback control. DVR Structure: State/ Output Feedback Control. UPQC -Structure and Control of Right - Shunt /Left - Shunt UPQC.

UNIT III SOLID STATE LIMITING, BREAKING AND TRANSFERRING DEVICES 9

Solid State Current Limiter (SSCL) - Current Limiter Topology, Operating principle. Solid State Breaker (SSB) - Issues in limiting and switching operations – Solid State Transfer Switch (SSTS) - Sag/Swell Detection algorithms: Algorithm based on Symmetrical Components/ Two- axis Transformation/ Instantaneous Symmetrical Components.

UNIT IV MODELLING AND SIMULATION TECHNIQUES FOR HARMONIC FILTERS 9

Real time – Digital time varying harmonic modeling and simulation techniques: Introduction – OFF LINE Harmonic modeling and simulation techniques-wave digital filters – discrete wavelet transform. Design of discrete value passive filters: Introduction-Sequential approximation method – Optimal filter design problem using ANN - Examples – Results.

UNIT V NEURO-FUZZY CONTROLLER FOR STATCOM 9

Introduction – adaptive critic designs – bench mark power system – ACD Neuro fuzzy controller structure-controller Training – simulation results – Practical considerations.

TOTAL: 45 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to:

- Describe the introduction of custom power devices.
- Explain the modeling and simulation techniques for harmonic filters.
- Create the STATCOM with neuro-fuzzy controller.
- Review on the unified power quality conditioner (UPQC) to improve electric power quality.
- Design discrete valve passive filters.

REFERENCES:

1. Arindam Ghosh, “Power Quality Enhancement Using Custom Power Devices”, Kluwer Academ ic Publishers, Boston, 2002.
2. Padiyar K.R, “FACTS Controllers in Power Transmission and Distribution”, New Age International (P) Limited, New Delhi, 2007.

3. Inigo Monedero et.al, “Classification of Electrical Disturbances in real time using Neural Networks ”, IEEE Transactions on Power Delivery, Vol. 22, No.3, Pg. 1288 - 1295, July 2007 .
4. Lof - Fu Pak et.al. , “Real time digital time varying harmonic modeling and Simulation techniques”, EEE Transactions on Power Delivery, Vol.22, No.2, Pg. 1218 - 1227, April 2007.
5. Ying - Pin Chang et.al, “Optimal design of discrete value passive harmonic filters using sequential neural network approximation and orthogonal array”, IEEE Transactions on Power Delivery, Vol.22, No.3, Pg.1813 - 1819, July 2007.

OPEN ELECTIVE

15PPE604 **SOFT COMPUTING**

L	T	P	C
3	0	0	3

OBJECTIVES:

- To provide adequate knowledge about FLC and NN toolbox.
- To expose the ideas about genetic algorithm.
- To provide adequate knowledge about feedback neural networks.

UNIT I INTRODUCTION AND ARTIFICIAL NEURAL NETWORKS 9

Introduction of soft computing - soft computing vs. hard computing- various types of soft computing techniques- applications of soft computing-Neuron- Nerve structure and synapse- Artificial Neuron and its model- activation functions- Neural network architecture- single layer and multilayer feed forward networks- McCullochPitts neuron model- perceptron model- Adaline and Madaline- multilayer perception model- back propogation learning methods- effect of learning rule coefficient - back propagation algorithm- factors affecting back propagation training applications.

UNIT II SPECIAL ARTIFICIAL NEURAL NETWORKS 9

Counter propagation network- architecture- functioning & characteristics of counter- Propagation network-Hopfield/ Recurrent network- configuration- stability constraints-associative memory and characteristics- limitations and applications- Hopfield v/s Boltzman machine- Adaptive Resonance Theory- Architecture- classifications-Implementation and training-Associative Memory.

UNIT III FUZZY LOGIC SYSTEM 9

Introduction to crisp sets and fuzzy sets- basic fuzzy set operation and approximate reasoning. Introduction to fuzzy logic modeling and control- Fuzzification- inference and defuzzification- Fuzzy knowledge and rule bases-Fuzzy modeling and control schemes for nonlinear systems. Self organizing fuzzy logic control- Fuzzy logic control for nonlinear time delay system.

UNIT IV GENETIC ALGORITHM 9

Basic concept of Genetic algorithm and detail algorithmic steps-adjustment of free Parameters- Solution of typical control problems using genetic algorithm- Concept on some other search techniques like tabu search and ant colony search techniques for solving optimization problems.

UNIT V HYBRID SYSTEMS 9

Integration of neural networks and fuzzy systems, adaptive neuro fuzzy inference systems, ANN- GA-Fuzzy synergism and its application, Identification and control of linear and nonlinear dynamic systems using MATLAB-neural network toolbox. Implementation of fuzzy logic controller using MATLAB fuzzy logic toolbox.

TOTAL: 45 Periods

COURSE OUTCOMES:

After successful completion of this course the students will be able to:

- Describe soft computing techniques and their roles in building intelligent machines.
- Identify the feasibility of applying a soft computing methodology for a particular problem.
- Apply fuzzy logic, genetic algorithm, neural networks and reasoning to handle uncertainty and solve engineering problems.
- Design a suitable soft computing technology to solve the power system /power electronics problem.
- Implement fuzzy logic controller using Matlab fuzzy logic toolbox.

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1. Timothy J. Ross, “Fuzzy Logic with Engineering Applications”,3rd Edition, Wiley, 2010.
2. Zimmermann H.J, "Fuzzy set theory and its Applications", Springer international edition, 2011.
3. Chaturvedi, “Soft Computing Techniques and its Applications in Electrical Engineering”, Springer, 2008
4. Laurene V. Fausett, “Fundamentals of Neural Networks: Architectures, Algorithms And Applications”, Pearson Education,1993.
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7. Jacek.M.Zurada, “Introduction to Artificial Neural Systems”, Jaico Publishing House, 1999.
8. KOSKO.B, “Neural Networks and Fuzzy Systems”, Prentice-Hall of India Pvt. Ltd., 1994.
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