AFFILIATED INSTITUTIONS

ANNA UNIVERSITY, CHENNAI

REGULATIONS - 2009

CURRICULUM AND SYLLABUS FOR I TO VI SEMESTERS (PART TIME)

M.E. POWER ELECTRONICS AND DRIVES - PART TIME

SEMESTER I

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	MA9216	Applied Mathematics for Electrical Engineers	3	1	0	4
2.	PE9211	Analysis of Electrical Machines	3	0	0	3
3.	PE9212	Analysis of Power Converters	3	0	0	3
		TOTAL	**9**	**1**	**0**	**10**

SEMESTER II

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	PE9221	Solid State DC Drives	3	0	0	3
2.	PE9222	Solid State AC Drives	3	0	0	3
3.	PE9223	Special Electrical Machines	3	0	0	3
		TOTAL	**9**	**0**	**0**	**9**

SEMESTER III

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	PE9213	Analysis of Inverters	3	0	0	3
2.	PE9214	Electromagnetic Field Computation and Modelling	3	1	0	4
3.		Elective – I	3	0	0	3
		TOTAL	**9**	**1**	**0**	**10**

SEMESTER IV

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	PE9224	Microcontroller and DSP Based System Design	3	0	0	3
2.		Elective – II	3	0	0	3
3.		Elective – III	3	0	0	3
PRACTICAL						
4.	PE9225	Power Electronics and Drives Lab	0	0	3	2
		TOTAL	**9**	**0**	**3**	**11**

SEMESTER V

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.		Elective – IV	3	0	0	3
2.		Elective – V	3	0	0	3
3.		Elective – VI	3	0	0	3
PRACTICAL						
4.	PE9231	Project – (Phase I)	0	0	12	6
		TOTAL	**9**	**0**	**12**	**15**

SEMESTER VI

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
PRACTICAL						
1.	PE9241	Project – (Phase II)	0	0	24	12
		TOTAL	**0**	**0**	**24**	**12**

TOTAL CREDITS TO BE EARNED FOR THE AWARD THE DEGREE = 67

ELECTIVES FOR M.E. POWER ELECTRONICS AND DRIVES

ELECTIVE I

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
1.	PS9214	System Theory	3	0	0	3
2.	PE9251	Control System design	3	0	0	3
3.	PE9252	Advanced power semiconductor devices	3	0	0	3

ELECTIVE II & III

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
4.	PS9223	Flexible AC Transmission Systems	3	0	0	3
5.	PE9261	Power Quality	3	0	0	3
6.	PE9262	Computer Aided Design of Power Electronics Circuits	**3**	**0**	**0**	**3**
7.	PE9263	Non linear control	3	0	0	3
8.	PE9264	Computer Aided Design of instrumentation systems	3	0	0	3
9.	PE9265	Advanced control systems	3	0	0	3

ELECTIVE IV, V, & VI

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
10.	PE9271	Electromagnetic Interference and Electromagnetic Compatibility	3	0	0	3
11.	PS9276	Wind Energy Conversion Systems	3	0	0	3
12.	PS9275	High Voltage Direct Current Transmission	3	0	0	3
13.	PE9272	Power Electronics for Renewable Energy Systems	3	0	0	3
14.	PE9273	System Identification and Adaptive control	3	0	0	3
15.	ET9274	Programming with VHDL	3	0	0	3
16.	ET9272	Advanced digital signal processing	3	0	0	3
17.	ET9278	Applications of MEMS Technology	3	0	0	3
18.	PE9274	Modern Rectifiers and resonant Converters	3	0	0	3
19.	PE9275	Soft Computing Techniques	3	0	0	3

MA 9216 APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERS **L T P C**
3 1 0 4

UNIT I ADVANCED MATRIX THEORY 12

Eigen-values using QR transformations – Generalized eigen vectors – Canonical forms – Singular value decomposition and applications – Pseudo inverse – Least square approximations.

UNIT II LINEAR PROGRAMMING 12

Formulation – Graphical Solution – Simplex Method – Two Phase Method – Transportation and Assignment Problems.

UNIT III ONE DIMENSIONAL RANDOM VARIABLES 12

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

UNIT IV QUEUEING MODELS 12

Poisson Process – Markovian queues – Single and Multi Serve r Models – Little's formula – Machine Interference Model – Steady State analysis – Self Service queue.

UNIT V COMPUTATIONAL METHODS IN ENGINEERING 12

Boundary value problems for ODE – Finite difference methods – Numerical solution of PDE – Solution of Laplace and Poisson equations – Liebmann's iteration process – Solution of heat conduction equation by Schmidt explicit formula and Crank-Nicolson implicit scheme – Solution of wave equation.

L +T: 45+15 = 60 PERIODS

REFERENCES

1. Bronson, R., Matrix Operation, Schaum's outline series, McGraw Hill, New York, (1989).
2. Taha, H. A.,Operations Research: An Introduction, Seventh Edition, Pearson Education Edition, Asia, New Delhi (2002).
3. R. E. Walpole, R. H. Myers, S. L. Myers, and K. Ye, Probability and Statistics for Engineers & Scientists, Asia, 8th Edition, (2007).
4. Donald Gross and Carl M. Harris, Fundamentals of Queueing theory, 2nd edition, John Wiley and Sons, New York (1985).
5. Grewal, B.S., Numerical methods in Engineering and Science, 7th edition, Khanna Publishers, 200

PE 9211 ANALYSIS OF ELECTRICAL MACHINES L T P C
3 0 0 3

UNIT I PRINCIPLES OF ELECTROMAGNETIC ENERGY CONVERSION 9
General expression of stored magnetic energy, co-energy and force/ torque – example using single and doubly excited system –Calculation of air gap mmf and per phase machine inductance using physical machine data.

UNIT II REFERENCE FRAME THEORY 9
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 DC MACHINES 9
Voltage and toque equations – dynamic characteristics of permanent magnet and shunt DC motors – state equations - solution of dynamic characteristic by Laplace transformation.

UNIT IV INDUCTION MACHINES 9
Voltage and toque equations – transformation for rotor circuits – voltage and toque equations in reference frame variables – analysis of steady state operation – free acceleration characteristics – dynamic performance for load and torque variations – dynamic performance for three phase fault – computer simulation in arbitrary reference frame.

UNIT V SYNCHRONOUS MACHINES 9
Voltage and Torque Equation – 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- dynamic performance for three phase fault – transient stability limit – critical clearing time – computer simulation.

TOTAL : 45 PERIODS

TEXT BOOKS:

1. Paul C.Krause, OlegWasyzczuk, Scott S, Sudhoff, "Analysis of Electric Machinery and Drive Systems", IEEE Press, Second Edition.
2. R.Krishnan, "Electric Motor Drives, Modeling, Analysis and Control" , Prentice Hall of India, 2002.

REFERENCES

1. Samuel Seely, " Eletomechanical Energy Conversion", Tata McGraw Hill Publishing Company,
2. A.E, Fitzgerald, Charles Kingsley, Jr, and Stephan D, Umanx, " Electric Machinery", Tata McGraw Hill, 5th Edition, 1992

PE 9212 ANALYSIS OF POWER CONVERTERS L T P C
3 0 0 3

UNIT I SINGLE PHASE AC-DC CONVERTER 12

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

UNIT II THREE PHASE AC-DC CONVERTER 9

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

UNIT III DC-DC CONVERTERS 9

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

UNIT IV AC VOLTAGE CONTROLLERS 9

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

UNIT V CYCLOCONVERTERS 6

Principle of operation – Single phase and three phase cycloconverters – power factor Control-Forced commutated cycloconverters.

TOTAL : 45 PERIODS

TEXT BOOKS:

1. Ned Mohan, Undeland and Robbin, "Power Electronics: converters, Application and design" John Wiley and sons.Inc, Newyork, 1995.
2. Rashid M.H., "Power Electronics Circuits, Devices and Applications ", Prentice Hal India, New Delhi, 1995.
3. Cyril W.Lander, "power electronics", Third Edition McGraw hill-1993

REFERENCES:

1. P.C Sen.," Modern Power Electronics ", Wheeler publishing Co, First Edition, New Delhi-1998.
2. P.S.Bimbra, "Power Electronics", Khanna Publishers, Eleventh Edition, 2003. power electronics by vedam subramanyam.

PE 9221 **SOLID STATE DC DRIVES** **L T P C**
3 0 0 3

UNIT I DC MOTORS FUNDAMENTALS AND MECHANICAL SYSTEMS 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.

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

UNIT II CONVERTER CONTROL 9

Principle of phase control – Fundamental relations; Analysis of series and separately excited DC motor with single-phase and three-phase converters – waveforms, performance parameters, performance characteristics.

Continuous and discontinuous armature current operations; Current ripple and its effect on performance; Operation with free wheeling diode; Implementation of braking schemes; Drive employing dual converter.

UNIT III CHOPPER CONTROL 9

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

UNIT IV CLOSED LOOP CONTROL 9

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

UNIT V DIGITAL CONTROL OF D.C 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

TEXT BOOKS:

1. Gopal K Dubey, “Power Semiconductor controlled Drives”, Prentice Hall Inc., New Yersy, 1989.
2. R.Krishnan, “Electric Motor Drives – Modeling, Analysis and Control”, Prentice-Hall of India Pvt. Ltd., New Delhi, 2003.

REFERENCES:

1. Gobal K.Dubey, “Fundamentals of Electrical Drives”, Narosal Publishing House, New Delhi, 2001.
2. Bimal K.Bose “Modern Power Electronics and AC Drives”, Pearson Education (Singapore) Pte. Ltd., New Delhi, 2003.
3. Vedam Subramanyam, “Electric Drives – Concepts and Applications”, Tata McGraw-Hill publishing company Ltd., New Delhi, 2002.
4. P.C Sen “Thyristor DC Drives”, John wiely and sons, New York, 1981

PE 9222 **SOLID STATE AC DRIVES** **L T P C**
3 0 0 3

UNIT I INTRODUCTION TO 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 – six step inverter voltage control-closed loop variable frequency PWM inverter with dynamic braking-CSI fed IM variable frequency drives comparison

UNIT III ROTOR CONTROLLED INDUCTION MOTOR DRIVES 9

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

UNIT IV FIELD ORIENTED CONTROL 9

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

UNIT V SYNCHRONOUS MOTOR DRIVES 9

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

TOTAL : 45 PERIODS

TEXT BOOKS

1. Bimal K Bose, "Modern Power Electronics and AC Drives", Pearson Education Asia 2002.
2. Vedam Subramanyam, "Electric Drives – Concepts and Applications", Tata McGraw Hill, 1994.
3. Gopal K Dubey, "Power Semiconductor controlled Drives", Prentice Hall Inc., New Yersy, 1989.
4. R.Krishnan, "Electric Motor Drives – Modeling, Analysis and Control", Prentice-Hall of India Pvt. Ltd., New Delhi, 2003.

REFERENCES

1. W.Leonhard, "Control of Electrical Drives", Narosa Publishing House, 1992.
2. Murphy J.M.D and Turnbull, "Thyristor Control of AC Motors", Pergamon Press, Oxford, 1988.

PE 9223 **SPECIAL ELECTRICAL MACHINES** **L T P C**
3 0 0 3

UNIT I SYNCHRONOUS RELUCTANCE MOTORS 9

Constructional features: axial and radial air gap Motors. Operating principle, reluctance torque – phasor diagram, motor characteristics – Linear induction machines.

UNIT II STEPPING MOTORS 9

Constructional features, principle of operation, modes of excitation torque production in Variable Reluctance (VR) stepping motor, Dynamic characteristics, Drive systems and circuit for open loop control, Closed loop control of stepping motor.

UNIT III SWITCHED RELUTANCE MOTORS 9

Constructional features-principle of operation-Torque equation-Power Controllers-Characteristics and control Microprocessor based controller.

UNIT IV PERMANENT MAGNET SYNCHRONOUS MOTORS 9

Principle of operation, EMF, power input and torque expressions, Phasor diagram, Power controllers, Torque speed characteristics, Self control, Vector control, Current control schemes.

UNIT V PERMANENT MAGNET BRUSHLESS DC MOTORS 9

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

TOTAL : 45 PERIODS

TEXT BOOKS

1. Miller, T.J.E. “Brushless permanent magnet and reluctance motor drives ", Clarendon Press, Oxford, 1989.
2. Kenjo, T, “Stepping motors and their microprocessor control ", Clarendon Press, Oxford, 1989.
3. LIM

REFERENCES

1. Kenjo, T and Naganori, S “Permanent Magnet and brushless DC motors ", Clarendon Press, Oxford, 1989.
2. Kenjo, T. Power Electronics for the microprocessor Age, 1989.
3. B.K. Bose, “Modern Power Electronics & AC drives”
4. R.Krishnan, “Electric Motor Drives – Modeling, Analysis and Control”, Prentice-Hall of India Pvt. Ltd., New Delhi, 2003.

PE 9213 ANALYSIS OF INVERTERS L T P C
3 0 0 3

UNIT I SINGLE PHASE INVERTERS 12

Introduction to self commutated switches : MOSFET and IGBT - 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.

UNIT III CURRENT SOURCE INVERTERS 9

Operation of six-step thyristor inverter – inverter operation modes – load – commutated inverters – Auto sequential current source inverter (ASCI) – current pulsations – comparison of current source inverter and voltage source inverters

UNIT IV MULTILEVEL INVERTERS 9

Multilevel concept – diode clamped – flying capacitor – cascade type multilevel inverters - Comparison of multilevel inverters - application of multilevel inverters

UNIT V RESONANT INVERTERS 6

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

TOTAL : 45 PERIODS

TEXT BOOKS

1. Rashid M.H., “Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Third Edition, New Delhi, 2004.
2. Jai P.Agrawal, “Power Electronics Systems”, Pearson Education, Second Edition, 2002.
3. Bimal K.Bose “Modern Power Electronics and AC Drives”, Pearson Education, Second Edition, 2003.
4. Ned Mohan,Undeland and Robbin, “Power Electronics: converters, Application and design” John Wiley and sons.Inc,Newyork,1995.
5. Philip T. krein, “Elements of Power Electronics” Oxford University Press -1998.

REFERENCES

1. P.C. Sen, “Modern Power Electronics”, Wheeler Publishing Co, First Edition, New Delhi, 1998.
2. P.S.Bimbra, “Power Electronics”, Khanna Publishers, Eleventh Edition, 2003.

PE 9214 ELECTROMAGNETIC FIELD COMPUTATION AND MODELLING **L T P C 3 1 0 4**

UNIT I INTRODUCTION 12

Review of basic field theory – electric and magnetic fields – Maxwell's equations – Laplace, Poisson and Helmoltz equations – principle of energy conversion – force/torque calculation – Electro thermal formulation.

UNIT II SOLUTION OF FIELD EQUATIONS I 12

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

UNIT III SOLUTION OF FIELD EQUATIONS II 12

Finite element method (FEM) – Differential/ integral functions – Variational method – Energy minimization – Discretisation – Shape functions –Stiffness matrix –1D and 2D planar and axial symmetry problem.

UNIT IV FIELD COMPUTATION FOR BASIC CONFIGURATIONS 12

Computation of electric and magnetic field intensities– Capacitance and Inductance – Force, Torque, Energy for basic configurations.

UNIT V DESIGN APPLICATIONS 12

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

L=45: T=15 TOTAL = 60 PERIODS

REFERENCES

1. K.J.Binns, P.J.Lawrenson, C.W Trowbridge, "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. S.J Salon, "Finite Element Analysis of Electrical Machines." Kluwer Academic Publishers, London, 1995, distributed by TBH Publishers & Distributors, Chennai, India
5. User manuals of MAGNET, MAXWELL & ANSYS software.
6. Silvester and Ferrari, "Finite Elements for Electrical Engineers" Cambridge University press, 1983.

PE 9224 MICROCONTROLLER AND DSP BASED SYSTEM DESIGN L T P C
3 0 0 3

UNIT I PIC 16C7X MICROCONTROLLER 9

Architecture memory organization – Addressing modes – Instruction set – Programming techniques – simple programs

UNIT II PERIPHERALS OF PIC 16C7X 9

Timers – interrupts – I/O ports – I^2C bus for peripheral chip access – A/D converter – UART

UNIT III MOTOR CONTROL SIGNAL PROCESSORS 9

Introduction- System configuration registers - Memory Addressing modes - Instruction set – Programming techniques – simple programs

UNIT IV PERIPHERALS OF SIGNAL PROCESSORS 9

General purpose Input/Output (GPIO) Functionality- Interrupts - A/D converter-Event Managers (EVA, EVB)- PWM signal generation

UNIT V APPLICATIONS OF PIC AND SIGNAL PROCESSORS 9

Voltage regulation of DC-DC converters- Stepper motor and DC motor control- Clarke's and parks transformation-Space vector PWM- Control of Induction Motors and PMSM.

TOTAL: 45 PERIODS

TEXT BOOKS

1. John B.Peatman , 'Design with PIC Microcontrollers,' Pearson Education, Asia 2004
2. Hamid A.Toliyat, Steven Campbell, 'DSP based electromechanical motion control', CRC Press

PE 9225 POWER ELECTONICS & DRIVES LAB L T P C
0 0 3 2

1. Micro controller based speed control of Converter/Chopper 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. DSP based speed control of SRM motor.

6. Self control operation of Synchronous motors.

7. Condition monitoring of three-phase induction motor under fault conditions.

8. Re-programmable Logic Devices and Programming

(a) VHDL programming – Examples

(b) Verilog HDL programming – Examples

(c) Realization of control logic for electric motors using FPGA.

9. Simulation of Four quadrant operation of three-phase induction motor.

10. Simulation of Automatic Voltage Regulation of three-phase Synchronous Generator.

11. Design of switched mode power supplies

TOTAL: 45 PERIODS

PE 9231 PROJECT WORK (PHASE I) L T P C
0 0 12 6

PE 9241 PROJECT WORK (PHASE – II) L T P C
0 0 24 12

PS 9214 SYSTEM THEORY L T P C
3 0 0 3

UNIT I STATE VARIABLE REPRESENTATION 9

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

UNIT II SOLUTION OF STATE EQUATION 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 Eigenvalues and Eigenvectors.

UNIT III CONTROLLABILITY AND OBSERVABILITY 9

Controllability and Observability-Stabilizability and Delectability-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

REFERENCES:

1. M. Gopal, “Modern Control System Theory”, New Age International, 2005.
2. K. Ogatta, “Modern Control Engineering”, PHI, 2002.
3. John S. Bay, “Fundamentals of Linear State Space Systems”, McGraw-Hill, 1999.
4. D. Roy Choudhury, “Modern Control Systems”, New Age International, 2005.
5. John J. D’Azzo, C. H. Houpis and S. N. Sheldon, “Linear Control System Analysis and Design with MATLAB”, Taylor Francis, 2003.
6. Z. Bubnicki, ”Modern Control Theory”, Springer, 2005.

PE9251	CONTROL SYSTEM DESIGN	L T P C
		3 0 0 3

UNIT I CONVENTIONAL DESIGN METHODS 9

Design specifications- PID controllers and compensators- Root locus based design-Bode based design-Design examples

UNIT II DESIGN IN DISCRETE DOMAIN 9

Sample and Hold-Digital equivalents-Impulse and step invariant transformations-Methods of discretisation-Effect of sampling- Direct discrete design – discrete root locus Design examples

UNIT III OPTIMAL CONTROL 9

Formation of optimal control problems-results of Calculus of variations- Hamiltonian formulation-solution of optimal control problems- Evaluation of Riccati’s equation State and output Regulator problems-Design examples

UNIT IV DISCRETE STATE VARIABLE DESIGN 9

Discrete pole placement- state and output feedback-estimated state feedback-discrete optimal control- dynamic programming-Design examples

UNIT V STATE ESTIMATION 9

State Estimation Problem -State estimation- Luenberger’s observer-noise characteristics- Kalman-Bucy filter-Separation Theorem-Controller Design-Wiener filter-Design examples.

TOTAL : 45 PERIODS

REFERENCES

1. M. Gopal “Modern control system Theory” New Age International, 2005.
2. Benjamin C. Kuo “Digital control systems”, Oxford University Press, 2004.
3. G. F. Franklin, J. D. Powell and A. E. Naeini “Feedback Control of Dynamic Systems”, PHI (Pearson), 2002.
4. Graham C. Goodwin, Stefan F. Graebe and Mario E. Salgado “Control system Design”, PHI (Pearson), 2003.
5. G. F. Franklin, J. D. Powell and M Workman, “Digital Control of Dynamic Systems”, PHI (Pearson), 2002.
6. B.D.O. Anderson and J.B. Moore., ‘Optimal Filtering’, Prentice hall Inc., N.J., 1979.
7. Loan D. Landau, Gianluca Zito,” Digital Control Systems, Design, Identification and Implementation”, Springer, 2006.

PE 9252 ADVANCED POWER SEMICONDUCTOR DEVICES L T P C
3 0 0 3

UNIT I INTRODUCTION 9

Power switching devices overview – Attributes of an ideal switch, application requirements, circuit symbols; Power handling capability – (SOA); Device selection strategy – On-state and switching losses – EMI due to switching - Power diodes - Types, forward and reverse characteristics, switching characteristics – rating.

UNIT II CURRENT CONTROLLED DEVICES 9

BJT’s – Construction, static characteristics, switching characteristics; Negative temperature co-efficient and secondary breakdown; Power darlington - Thyristors – Physical and electrical principle underlying operating mode, Two transistor analogy – concept of latching; Gate and 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 of voltage controlled devices, construction, types, static and switching characteristics, steady state and dynamic models of MOSFET and IGBTs - Basics of GTO, MCT, FCT, RCT and IGCT.

UNIT IV FIRING AND PROTECTING CIRCUITS 9

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

UNIT V THERMAL PROTECTION 9

Heat transfer – conduction, convection and radiation; Cooling – liquid cooling, vapour – phase cooling; Guidance for hear sink selection – Thermal resistance and impedance - Electrical analogy of thermal components, heat sink types and design – Mounting types.

TOTAL : 45 PERIODS

TEXT BOOKS

1. B.W Williams ‘Power Electronics Circuit Devices and Applications’.
2. Rashid M.H., " Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Third Edition, New Delhi, 2004.

REFERENCES

1. MD Singh and K.B Khanchandani, “Power Electronics”, Tata McGraw Hill, 2001.
2. Mohan, Undcland and Robins, “Power Electronics – Concepts, applications and Design, John Wiley and Sons, Singapore, 2000.

PS 9223 FLEXIBLE AC TRANSMISSION SYSTEMS L T P C
3 0 0 3

UNIT I INTRODUCTION 9

Reactive power control in electrical power transmission lines -Uncompensated transmission line - series compensation – Basic concepts of static Var Compensator (SVC) – Thyristor Switched Series capacitor (TCSC) – Unified power flow controller (UPFC).

UNIT II STATIC VAR COMPENSATOR (SVC) AND APPLICATIONS 9

Voltage control by SVC – Advantages of slope in dynamic characteristics – Influence of SVC on system voltage – Design of SVC voltage regulator –Modelling of svc for power flow and transient stability – Applications: Enhancement of transient stability – Steady state power transfer – Enhancement of power system damping – Prevention of voltage instability.

UNIT III THYRISTOR CONTROLLED SERIES CAPACITOR (TCSC) AND APPLICATIONS 9

Operation of the TCSC – Different modes of operation – Modelling of TCSC – Variable reactance model – Modelling for Power Flow and stability studies. Applications: Improvement of the system stability limit – Enhancement of system damping-SSR Mitigation.

UNIT IV VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS 9

Static Synchronous Compensator (STATCOM) – Principle of operation – V-I Characteristics. Applications: Steady state power transfer-Enhancement of transient stability - Prevention of voltage instability. SSSC-operation of SSSC and the control of power flow –Modelling of SSSC in load flow and transient stability studies. Applications: SSR Mitigation-UPFC and IPFC

UNIT V CO-ORDINATION OF FACTS CONTROLLERS 9

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

TOTAL : 45 PERIODS

REFERENCES

1. R.Mohan Mathur, Rajiv K.Varma, "Thyristor – Based Facts Controllers for Electrical Transmission Systems", IEEE press and John Wiley & Sons, Inc.
2. Narain G. Hingorani, "Understanding FACTS -Concepts and Technology of Flexible AC Transmission Systems", Standard Publishers Distributors, Delhi- 110 006
3. K.R.Padiyar," FACTS Controllers in Power Transmission and Distribution", New Age International(P) Limited, Publishers, New Delhi, 2008
4. A.T.John, "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, APRIL 2004 , Kluwer Academic Publishers.

PE 9261 POWER QUALITY LT P C
3 0 0 3

UNIT I INTRODUCTION 9

Introduction – Characterisation of Electric Power Quality: Transients, short duration and long duration voltage variations, Voltage imbalance, waveform distortion, Voltage fluctuations, Power frequency variation, Power acceptability curves – 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 NON-LINEAR LOADS 9

Single phase static and rotating AC/DC converters, Three phase static AC/DC converters, Battery chargers, Arc furnaces, Fluorescent lighting, pulse modulated devices, Adjustable speed drives.

UNIT III MEASUREMENT AND ANALYSIS METHODS 9

Voltage, Current, Power and Energy measurements, power factor measurements and definitions, event recorders, Measurement Error – Analysis: Analysis in the periodic steady state, Time domain methods, Frequency domain methods: Laplace's, Fourier and Hartley transform – The Walsh Transform – Wavelet Transform.

UNIT IV ANALYSIS AND CONVENTIONAL MITIGATION METHODS 9

Analysis of power outages, Analysis of unbalance: Symmetrical components of phasor quantities, Instantaneous symmetrical components, Instantaneous real and reactive powers, Analysis of distortion: On–line extraction of fundamental sequence components from measured samples – Harmonic indices – Analysis of voltage sag: Detorit Edison sag score, Voltage sag energy, Voltage Sag Lost Energy Index (VSLEI)- Analysis of voltage flicker, Reduced duration and customer impact of outages, Classical load balancing problem: Open loop balancing, Closed loop balancing, current balancing, Harmonic reduction, Voltage sag reduction.

UNIT POWER QUALITY IMPROVEMENT 9

Utility-Customer interface –Harmonic filters: passive, Active and hybrid filters –Custom power devices: Network reconfiguring Devices, Load compensation using DSTATCOM, Voltage regulation using DSTATCOM, protecting sensitive loads using DVR, UPQC – control strategies: P-Q theory, Synchronous detection method – Custom power park – Status of application of custom power devices.

TOTAL : 45 PERIODS

TEXT BOOKS

1. Arindam Ghosh "Power Quality Enhancement Using Custom Power Devices", Kluwer Academic Publishers, 2002
2. G.T.Heydt, "Electric Power Quality", Stars in a Circle Publications, 1994(2nd edition)
3. Power Quality - R.C. Duggan
4. Power system harmonics –A.J. Arrillga
5. Power electronic converter harmonics –Derek A. Paice

PE9262 COMPUTER AIDED DESIGN OF POWER ELECTRONIC CIRCUITS

L T P C
3 0 0 3

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, 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 Cyclo-converters feeding R, R-L, and R-L-E loads – computation of performance parameters: harmonics, power factor, angle of overlap.

TOTAL : 45 PERIODS

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.

PE 9263 NONLINEAR CONTROL L T P C
3 0 0 3

UNIT I PHASE PLANE ANALYSIS 9

Concepts of phase plane analysis- Phase portraits- singular points- Symmetry in phase plane portraits-Constructing Phase Portraits- Phase plane Analysis of Linear and Nonlinear Systems- Existence of Limit Cycles.

UNIT II DESCRIBING FUNCTION 9

Describing Function Fundamentals-Definitions-Assumptions-Computing Describing Functions-Common Nonlinearities and its Describing Functions-Nyquist Criterion and its Extension-Existence of Limit Cycles-Stability of limit Cycles.

UNIT III LYAPUNOV THEORY 9

Nonlinear Systems and Equilibrium Points-Concepts of Stability-Linearization and Local Stability-Lyapunov's Direct Method-Positive definite Functions and Lyapunov Functions-Equilibrium Point Theorems-Invariant Set Theorems-LTI System Analysis based on Lyapunov's Direct Method-Krasovski's Method-Variable Gradient Method-Physically – Control Design based on Lyapunov's Direct Method.

UNIT IV FEEDBACK LINEARIZATION 9

Feedback Linearization and the Canonical Form-Mathematical Tools-Input-State Linearization of SISO Systems- input-Output Linearization of SISO Systems-Generating a Linear Input-Output Relation-Normal Forms-The Zero-Dynamics-Stabilization and Tracking-Inverse Dynamics and Non-Minimum-Phase Systems-Feedback Linearization of MIMO Systems Zero-Dynamics and Control Design.

UNIT V SLIDING MODE CONTROL 9

Sliding Surfaces- Continuous approximations of Switching Control laws-The Modeling/Performance Trade-Offs-MIMO Systems.

TOTAL : 45 PERIODS

REFERENCES

1. J A E Slotine and W Li, Applied Nonlinear control, PHI, 1991.
2. Hasan Khalil, "Nonlinear systems and control", Prentice Hall.
3. S H Zak, "Systems and control", Oxford University Press, 2003.
4. Torkel Glad and Lennart Ljung, "Control Theory – Multivariable and Nonlinear Methods", Taylor & Francis, 2002.
5. G. J. Thaler, "Automatic control systems", Jaico publishers, 1993.
6. P.Albertos, A. Sala," Multivariable Control System", Springer, 2004

PE 9264 COMPUTER AIDED DESIGN OF INSTRUMENTATION SYSTEMS L T P C
3 0 0 3

UNIT I DATA ACQUISITION AND INSTRUMENT INTERFACE 9

Programming and simulation of Building block of instrument Automation system – Signal analysis, I/O port configuration with instrument bus protocols - ADC, DAC, DIO, counters & timers, PC hardware structure, timing, interrupts, DMA, software and hardware installation, current loop, RS 232/RS485, GPIB, USB protocols,

UNIT II VIRTUAL INSTRUMENTATION PROGRAMMING TECHNIQUES 9

Block diagram and architecture of a virtual instrument, Graphical programming in data flow, comparison with conventional programming, Vis and sub-Vis, loops and charts, arrays, clusters and graphs, case and sequence structures, formula nodes, local and global variables, string and file I/O.

UNIT III DESIGN TEST & ANALYSIS 9

Spectral estimation using Fourier Transform, power spectrum, correlation methods, Stability analysis, Fault analysis –Sampling, Data Parity and error coding checks, Synchronization testing – Watch dog timer, DMA method – Real-time Clocking, Noise-Gaussian, White analysis

UNIT IV PC BASED INSTRUMENTATION 9

Introduction – Evolution of signal standard – HART Communication protocol – Communication modes – HART networks – control system interface – HART commands – HART field controller implementation – HART and the OSI model

UNIT V SIMULATION OF PHYSICAL SYSTEMS 9

Simulation of linear & Non-linear models of systems, Hardware in loop simulation of physical systems using special softwares.

TOTAL : 45 PERIODS

REFERENCES

1. K. Ogatta, “Modern control Engineering”, Fourth edition, Perason education 2002.
2. Dorf and Bishop, “Modern Control Engineering”, Addison Weseley, 1998.
3. Patrick H. Garrett,” High performance Instrumentation and Automation”, CRC Press, Taylor & Francis Group, 2005.
4. MAPLE V programming guide
5. MATLAB/SIMULINK user manual
6. MATHCAD/VIS SIM user manual.
7. LABVIEW simulation user manual

PE 9265 ADVANCED CONTROL SYSTEMS L T P C
3 0 0 3

UNIT I CLASSICAL CONTROLLER DESIGN 9

Proportional(P)-Integral(I)-Derivative(D)-PI-PD - PID Controllers-Characteristics-Design-Controller Tuning- - Ziegler-Nichol’s method and cohen coon method – Damped oscillation method

UNIT II STATE SPACE DESCRIPTION & DESIGN 9

Review of state model for systems-state transition matrix –controllability-observability-Kalman decomposition-state feedback-output feedback-design methods-pole placement controller -full order and reduced order observers-dead beat control

UNIT NON LINEAR SYSTEMS 9

Types of non-linearity-typical examples-describing function method-phase plane analysis-stability analysis of non linear systems- Lyapunov function – Construction of Lyapunov function- Lyapunov's direct method- Lyapunov's indirect method

UNIT IV OPTIMAL CONTROL 9

Statement of optimal control problem – Problem formulation and forms of optimal control – Performance measures for optimal control – Selection of performance measure – Various methods of optimization- Necessary conditions for optimal control – Linear Quadratic regulator problem-Algebraic Riccati Equation –Solving ARE using Eigen vector method

UNIT V DIGITAL CONTROL SYSTEMS 9

Pulse transfer function-State equation – Solutions – Realization – Controllability – Observability – Stability – Jury's test.-Digital Controller Design-Direct design method –Pole Placement controller-Dead beat Control- Discrete-Linear Quadratic regulator.

TOTAL : 45 PERIODS

TEXT BOOKS

1. J.Nagrath and M.Gopal "Control System Engineering", new age international publishers, 2003
2. M.Gopal "Modern Control System Theory", New Age International Ltd., 2002.
3. Ogata" Modern Control Systems"

REFERENCES

1. Donald P.Eckman,Automatic Process Control",Wiley Eastern Ltd.,New Delhi,1993.
2. Benjamine C.Kuo,"Digital Control Systems",Oxford University Press,1992.
3. B.Sarkar," Control system design-The Optimal Approach",Wheeler Publishing ,New Delhi,1997

PE 9271	**ELECTROMAGNETIC INTERFERENCE AND ELECTROMAGNETIC COMPATIBILITY**	**L T P C** **3 0 0 3**

UNIT I INTRODUCTION 9

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

UNIT II METHOD OF HARDENING 9

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

UNIT III BALANCING, FILTERING AND SHIELDING 9

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

UNIT IV DIGITAL CIRCUIT NOISE AND LAYOUT 9

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

UNIT V ELECTROSTATIC DISCHARGE,STANDARDS AND LABORATORY TECHNIQUES 9

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

TOTAL : 45 PERIODS

REFERENCES

1. Henry W.Ott, " Noise reduction techniques in electronic systems", John Wiley & Sons, 1989.
2. Bernhard Keiser, "Principles of Electro-magnetic Compatibility", Artech House, Inc. (685 canton street, Norwood, MA 020062 USA) 1987.
3. Bridges, J.E Milleta J. and Ricketts.L.W., "EMP Radiation and Protective techniques", John Wiley and sons, USA 1976.
4. IEEE National Symposium on "Electromagnetic Compatibility", IEEE, 445, hoes Lane, Piscataiway, NJ 08855.

PS 9276 WIND ENERGY CONVERSION SYSTEMS

L T P C
3 0 0 3

UNIT I INTRODUCTION 9

Components of WECS-WECS schemes-Power obtained from wind-simple momentum theory-Power coefficient-Sabinin's theory-Aerodynamics of Wind turbine

UNIT II WIND TURBINES 9

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

Stand alone and Grid Connected WECS system-Grid connection Issues-Machine side & Grid side controllers-WECS in various countries

TOTAL : 45 PERIODS

REFERENCES

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

PS 9275 HIGH VOLTAGE DIRECT CURRENT TRANSMISSION L T P C
3 0 0 3

UNIT I DC POWER TRANSMISSION TECHNOLOGY 6

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

UNIT II ANALYSIS OF HVDC CONVERTERS AND HVDC SYSTEM CONTROL 12

Pulse number, choice of converter configuration – Simplified analysis of Graetz circuit - Converter bridge characteristics – characteristics of a twelve pulse converter- detailed analysis of converters.

General principles of DC link control – Converter control characteristics – System Control hierarchy - Firing angle control – Current and extinction angle control – Generation of harmonics and filtering - power control – Higher level controllers.

UNIT III MULTITERMINAL DC SYSTEMS 9

Introduction – Potential applications of MTDC systems - Types of MTDC systems - Control 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 - Modelling 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

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

PE 9272 POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS

L	T	P	C
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UNIT I INTRODUCTION 9

Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (cost-GHG Emission) - Qualitative study of different renewable energy resources: Solar, wind, ocean, Biomass, Fuel cell, Hydrogen energy systems and hybrid renewable energy systems.

UNIT II ELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION 9

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

UNIT III POWER CONVERTERS 9

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

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

UNIT IV ANALYSIS OF WIND AND PV SYSTEMS 9

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

UNIT V HYBRID RENEWABLE ENERGY SYSTEMS 9

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

TOTAL : 45 PERIODS

REFERENCES:
1. Rashid .M. H "power electronics Hand book", Academic press, 2001.
2. Rai. G.D, "Non conventional energy sources", Khanna publishes, 1993.
3. Rai. G.D," Solar energy utilization", Khanna publishes, 1993.
4. Gray, L. Johnson, "Wind energy system", prentice hall Iinc, 1995.
5. Non-conventional Energy sources B.H.Khan Tata McGraw-hill Publishing Company, New Delhi.

PE9273 SYSTEM IDENTIFICATION AND ADAPTIVE CONTROL **L T P C**
3 0 0 3

UNIT I MODELS FOR INDENTIFICATION 9

Models of LTI systems: Linear Models-State space Models-OE model- Model sets, Structures and Identifiability-Models for Time-varying and Non-linear systems: Models with Nonlinearities – Non-linear state-space models-Black box models, Fuzzy models'.

UNIT II NON-PARAMETRIC AND PARAMETRIC IDENTIFICATON 9

Transient response and Correlation Analysis – Frequency response analysis – Spectral Analysis – Least Square – Recursive Least Square –Forgetting factor- Maximum Likelihood – Instrumental Variable methods.

UNIT III NON-LINEAR IDENTIFICATION AND MODEL VALIDATION 9

Open and closed loop identification: Approaches – Direct and indirect identification – Joint input-output identification – Non-linear system identification – Wiener models – Power series expansions - State estimation techniques – Non linear identification using Neural Network and Fuzzy Logic.

UNIT IV 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 V CASE STUDIES 9

Inverted Pendulum, Robot arm, process control application: heat exchanger, Distillation column, application to power system, Ship steering control.

TOTAL: 45 PERIODS

REFERENCES

1. Ljung," System Identification Theory for the User", PHI, 1987.
2. Torsten Soderstrom, Petre Stoica, "System Identification", prentice Hall ` International (UK) Ltd,1989.
3. Astrom and Wittenmark," Adaptive Control ", PHI.
4. William S. Levine, " Control Hand Book".
5. Narendra and Annasamy," Stable Adaptive Control Systems, Prentice Hall, 1989.

ET 9274 PROGRAMMING WITH VHDL **L T P C**
3 0 0 3

UNIT I VHDL FUNDAMENTALS 9

Fundamental concepts- Modeling digital system-Domain and levels of modeling-modeling languages-VHDL modeling concepts-Scalar Data types and operations-constants and Variable-Scalar Types- Type Classification-Attributes and scalar types-expression and operators-Sequential statements.

UNIT II DATA TYPES AND BASIC MODELING CONSTRUCTS 9

Arrays- unconstrained array types-array operations and referencing- records - Access Types- Abstract Date types- -basic modeling constructs-entity declarations-Architecture bodies-behavioral description-structural descriptions- design Processing, case study: A pipelined Multiplier accumulator.

UNIT III SUBPROGRAMS , PACKAGES AND FILES 9

Procedures-Procedure parameters- Concurrent procedure call statements –Functions – Overloading –visibility of Declarations-packages and use clauses- Package declarations-package bodies-use clauses-Predefined aliases-Aliases for Data objects-Aliases for Non-Data items-Files- I/O-Files. Case study: A bit vector arithmetic Package.

UNIT IV SIGNALS, COMPONENTS, CONFIGURATIONS 9

Basic Resolved Signals-IEEE std_Logic_1164 resolved subtypes- resolved Signal Parameters - Generic Constants- Parameterizing behavior- Parameterizing structure-components and configurations-Generate Statements-Generating Iterative structure-Conditionally generating structure-Configuration of generate statements-case study: DLX computer Systems.

UNIT V DESIGN WITH PROGRAMMABLE LOGIC DEVICES 9

Realization of -Micro controller CPU.- Memories-I/O devices-MAC-Design, synthesis, simulation and testing.

TOTAL: 45 PERIODS

REFERENCES

1. Peter J.Ashenden, “The Designer’s guide to VHDL”, Morgan Kaufmann publishers,San Francisco,Second Edition, May 2001.
2. Zainalabedin navabi, “VHDL Analysis ans modeling of Digital Systems”, McGraw Hill international Editions, Second Editions, 1998.
3. Charles H Roth, Jr. “Digital system Design using VHDL”, Thomson ,2006.
4. Douglas Perry, “VHDL Programming by Example”, Tata McGraw Hill,4th Edition 2002.
5. Navabi.Z., “VHDL Analysis and Modeling of Digital Systems”, McGraw International, 1998.
6. Peter J Ashendem, “The Designers Guide to VHDL”, Harcourt India Pvt Ltd, 2002
7. Skahill. K, “VHDL for Programmable Logic”, Pearson education, 1996.

ET 9272 ADVANCED DIGITAL SIGNAL PROCESSING L T P C
3 0 0 3

UNIT I INTRODUCTION 9

Mathematical description of change of sampling rate – Interpolation and Decimation, Filter implementation for sampling rate conversion – direct form FIR structures, DTFT, FFT, Wavelet transform and filter bank implementation of wavelet expansion of signals

UNIT II ESTIMATION AND PREDICTION TECHNIQUES 9

Discrete Random Processes – Ensemble averages, Stationary processes, Autocorrelation and Auto covariance matrices. Parseval’s Theorem, Wiener-Khintchine Relation – Power Spectral Density**.** AR, MA, ARMA model based spectral estimation. Parameter Estimation, Linear prediction – Forward and backward predictions, Least mean squared error criterion – Wiener filter for filtering and prediction, Discrete Kalman filter.

UNIT III DIGITAL SIGNAL PROCESSOR 9

Basic Architecture – Computational building blocks, MAC, Bus Architecture and memory, Data Addressing, Parallelism and pipelining, Parallel I/O interface, Memory Interface, Interrupt, DMA.

UNIT IV APPLICATION OF DSP 9

Design of Decimation and Interpolation Filter, FFT Algorithm, PID Controller, Application for Serial Interfacing, DSP based Power Meter, Position control.

UNIT V VLSI IMPLEMENTATION 9

Basics on DSP sytem architecture design using VHDL programming, Mapping of DSP algorithm onto hardware, Realisation of MAC & Filter structure.

TOTAL : 45 PERIODS

REFERENCES

1. Bernard Widrow, Samuel D. Stearns, “Adaptive Signal Processing”, Pearson Education, third edition, 2004.
2. Dionitris G. Manolakis, Vinay K. Ingle, Stepen M. Kogon,”Statistical & Adaptive signal processing, spectral estimation, signal modeling, Adaptive filtering & Array processing”, McGraw-Hill International edition 2000.
3. Monson H. Hayes, “Statistical Digital Signal Processing and Modelling”, John Wiley And Sons, Inc.,
4. John G. Proaks, Dimitris G. Manolakis, “Digital Signal Processing”, Pearson Education 2002.
5. S. Salivahanan, A. Vallavaraj and C. Gnanapriya “Digital Signal Processing”, TMH,2000.
6. Avatar Sing, S. Srinivasan, “Digital Signal Processing- Implementation using DSP Microprocessors with Examples from TMS320C54xx”, Thomson India, 2004.
7. Lars Wanhammer, “DSP Integrated Circuits”, Academic press, 1999,New York.
8. Ashok Ambardar,”Digital Signal Processing: A Modern Introduction”,Thomson India edition, 2007.
9. Lars Wanhammer, “DSP Integrated Circuits”, Academic press, 1999,New York.

ET 9278 APPLICATIONS OF MEMS TECHNOLOGY L T P C
3 0 0 3

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

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

UNIT III THERMAL SENSING AND ACTUATION 9

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

UNIT IV PIEZOELECTRIC SENSING AND ACTUATION 9

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

UNIT V CASE STUDIES 9

Piezoresistive sensors, Magnetic actuation, Micro fluidics applications, Medical applications, Optical MEMS.

TOTAL : 45 PERIODS

REFERENCES

1. Chang Liu, "Foundations of MEMS", Pearson International Edition, 2006.
2. Marc Madou , "Fundamentals of microfabrication",CRC Press, 1997.
3. Boston , "Micromachined Transducers Sourcebook",WCB McGraw Hill, 1998.
4. M.H.Bao "Micromechanical transducers :Pressure sensors, accelerometers and gyroscopes", Elsevier, Newyork, 2000.

PE 9274 MODERN RECTIFIERS AND RESONANT CONVERTERS

L T P C
3 0 0 3

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-Behaviour 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-Single phase 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.

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.

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

REFERENCES

1. Robert W. Erickson &Dragon Maksimovic" Fundamentals of Power Electronics" Second Edition, 2001 Springer science and Business media
2. William Shepherd and Li zhang" Power Converters Circuits"Marceld Ekkerin,C.
3. Simon Ang and Alejandro Oliva "Power- Switching Converters" Taylor & Francis Group

PE 9275 SOFT COMPUTING TECHNIQUES L T P C
3 0 0 3

UNIT I INTRODUCTION 9

Approaches to intelligent control. Architecture for intelligent control. Symbolic reasoning system, rule-based systems, the AI approach. Knowledge representation. Expert systems.

UNIT II ARTIFICIAL NEURAL NETWORKS 9

Concept of Artificial Neural Networks and its basic mathematical model, McCulloch-Pitts neuron model, simple perceptron, Adaline and Madaline, Feed-forward Multilayer Perceptron. Learning and Training the neural network. Data Processing: Scaling, Fourier transformation, principal-component analysis and wavelet transformations. Hopfield network, Self-organizing network and Recurrent network. Neural Network based controller

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, inferencing 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 and-colony search techniques for solving optimization problems.

UNIT V APPLICATIONS 9

GA application to power system optimization problem, Case studies: Identification and control of linear and nonlinear dynamic systems using Matlab-Neural Network toolbox. Stability analysis of Neural-Network interconnection systems. Implementation of fuzzy logic controller using Matlab fuzzy-logic toolbox. Stability analysis of fuzzy control systems.

TOTAL : 45 PERIODS

REFERENCES

1. Jacek.M.Zurada, "Introduction to Artificial Neural Systems", Jaico Publishing House, 1999.
2. KOSKO,B. "Neural Networks And Fuzzy Systems", Prentice-Hall of India Pvt. Ltd., 1994.
3. KLIR G.J. & FOLGER T.A. "Fuzzy sets, uncertainty and Information", Prentice-Hall of India Pvt. Ltd., 1993.
4. Zimmerman H.J. "Fuzzy set theory-and its Applications"-Kluwer Academic Publishers, 1994.
5. Driankov, Hellendroon, "Introduction to Fuzzy Control", Narosa Publishers.