GOVERNMENT COLLEGE OF TECHNOLOGY

(An Autonomous Institution Affiliated to Anna University)

Coimbatore - 641 013

Regulations, Curriculum And Syllabi For

M.E. (POWER ELECTRONICS AND DRIVES)

(Full Time & Part Time)

2012

Regulations

OFFICE OF THE CONTROLLER OF EXAMINATIONS,
GOVERNMENT COLLEGE OF TECHNOLOGY,
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Curriculum

CURRICULUM FOR CANDIDATES ADMITTED
DURING 2012-2013 AND ONWARDS
BRANCH: M.E. (POWER ELECTRONICS AND DRIVES) – FULL TIME

FIRST SEMESTER

S. No.	Subject Code	Course title	Sessional marks	Final Exam marks	Total marks	L	T	P	C
1	12PE01	APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERING	25	75	100	3	1	0	4
2	12PE02	SYSTEMS THEORY	25	75	100	3	0	0	3
3	12PE03	POWER SEMICONDUCTOR DEVICES AND APPLICATIONS	25	75	100	3	0	0	3
4	12PE04	ANALYSIS OF CONVERTERS	25	75	100	3	0	0	3
5	12PE05	ANALYSIS OF INVERTERS	25	75	100	3	0	0	3
6	E1	ELECTIVE - I	25	75	100	3	0	0	3
		TOTAL			**600**				**19**

SECOND SEMESTER

S. No.	Subject Code	Course title	Sessional marks	Final Exam marks	Total marks	L	T	P	C
1	12PE06	SOLID STATE DC DRIVES	25	75	100	3	0	0	3
2	12PE07	SOLID STATE AC DRIVES	25	75	100	3	0	0	3
3	12PE08	SPECIAL MACHINES AND CONTROLLERS	25	75	100	3	0	0	3
4	12PE09	POWER ELECTRONICS SIMULATION LAB	25	75	100	0	0	3	2
5	E2	ELECTIVE - II	25	75	100	3	0	0	3
6	E3	ELECTIVE - III	25	75	100	3	0	0	3
		TOTAL			**600**				**17**

THIRD SEMESTER

S. No.	Subject Code	Course title	Sessional marks	Final Exam marks	Total marks	Credits			
						L	T	P	C
1	E4	ELECTIVE - IV	25	75	100	3	0	0	3
2	E5	ELECTIVE - V	25	75	100	3	0	0	3
3	E6	ELECTIVE - VI	25	75	100	3	0	0	3
4	12PE10	PROJECT -I AND VIVA-VOCE	50	150	200	0	0	12	6
		TOTAL			**500**				**15**

FOURTH SEMESTER

S. No.	Subject Code	Course title	Sessional marks	Final Exam marks	Total marks	Credits			
						L	T	P	C
1	12PE11	PROJECT -II AND VIVA-VOCE	100	300	400	0	0	24	12
		TOTAL			**400**				**12**

Total Credits: 19 + 17 + 15 + 12 = 63

L : Credits for Lecture Hours T : Credits for Tutorial Hours

P : Credits for Practical Hours C : Total Number of Credits

CURRICULUM FOR CANDIDATES ADMITTED
DURING 2012-2013 AND ONWARDS
BRANCH: M.E. (POWER ELECTRONICS AND DRIVES) – PART TIME

FIRST SEMESTER

S. No.	Subject Code	Course title	Sessional marks	Final Exam marks	Total marks	Credits			
						L	T	P	C
1	12PE01	APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERING	25	75	100	3	1	0	4
2	12PE02	SYSTEMS THEORY	25	75	100	3	0	0	3
3	12PE03	POWER SEMICONDUCTOR DEVICES AND APPLICATIONS	25	75	100	3	0	0	3
		TOTAL			300				**10**

SECOND SEMESTER

S. No.	Subject Code	Course title	Sessional marks	Final Exam marks	Total marks	Credits			
						L	T	P	C
1	12PE06	SOLID STATE DC DRIVES	25	75	100	3	0	0	3
2	12PE07	SOLID STATE AC DRIVES	25	75	100	3	0	0	3
3	12PE08	SPECIAL MACHINES AND CONTROLLERS	25	75	100	3	0	0	3
		TOTAL			**300**				**9**

THIRD SEMESTER

S. No.	Subject Code	Course title	Sessional marks	Final Exam marks	Total marks	Credits			
						L	T	P	C
1	12PE04	ANALYSIS OF CONVERTERS	25	75	100	3	0	0	3
2	12PE05	ANALYSIS OF INVERTERS	25	75	100	3	0	0	3
3	E1	ELECTIVE - I	25	75	100	3	0	0	3
		TOTAL			**300**				**9**

FOURTH SEMESTER

S. No.	Subject Code	Course title	Sessional marks	Final Exam marks	Total marks	Credits			
						L	T	P	C
1	12PE09	POWER ELECTRONICS SIMULATION LAB	25	75	100	0	0	3	2
2	E2	ELECTIVE - II	25	75	100	3	0	0	3
3	E3	ELECTIVE - III	25	75	100	3	0	0	3
		TOTAL			**300**				**8**

FIFTH SEMESTER

S. No.	Subject Code	Course title	Sessional marks	Final Exam marks	Total marks	Credits			
						L	T	P	C
1	E4	ELECTIVE - IV	25	75	100	3	0	0	3
2	E5	ELECTIVE - V	25	75	100	3	0	0	3
3	E6	ELECTIVE - VI	25	75	100	3	0	0	3
4	12PE10	PROJECT -I AND VIVA-VOCE	50	150	200	0	0	12	6
		TOTAL			**500**				**15**

SIXTH SEMESTER

S. No.	Subject Code	Course title	Sessional marks	Final Exam marks	Total marks	Credits			
						L	T	P	C
1	12PE11	PROJECT -II AND VIVA-VOCE	100	300	400	0	0	24	12
		TOTAL			**400**				**12**

Total Credits : 10 + 9 + 9 + 8 + 15 + 12 = 63

L : Credits for Lecture Hours T : Credits for Tutorial Hours

P : Credits for Practical Hours C : Total Number of Credits

LIST OF ELECTIVES FOR M.E. POWER ELECTRONICS AND DRIVES

S. No.	Subject Code	Course title	Sessional marks	Final Exam marks	Total marks	Credits			
						L	T	P	C
		ELECTIVE I							
1	12PE12	NON LINEAR SYSTEMS	25	75	100	3	0	0	3
2	12PE13	HIGH VOLTAGE DC TRANSMISSION SYSTEMS	25	75	100	3	0	0	3
3	12PE14	MODELLING AND ANALYSIS OF ELECTRICAL MACHINES	25	75	100	3	0	0	3
4	12PE15	COMPUTER AIDED DESIGN OF ELECTRICAL MACHINES	25	75	100	3	0	0	3
5	12PE16	MODERN CONVERTERS AND CONTROL TECHNIQUES	25	75	100	3	0	0	3
		ELECTIVE II							
6	12PE17	MICROCONTROLLER BASED SYSTEM DESIGN	25	75	100	3	0	0	3
7	12PE18	DIGITAL SIGNAL PROCESSING AND CONTROL	25	75	100	3	0	0	3
8	12PE19	VHDL BASED DIGITAL SYSTEM DESIGN	25	75	100	3	0	0	3
9	12PE20	REAL TIME EMBEDDED SYSTEMS	25	75	100	3	0	0	3
10	12PE21	SIMULATION OF POWER ELECTRONIC SYSTEMS	25	75	100	3	0	0	3
		ELECTIVE III							
11	12PE22	CONTROL SYSTEM SOFTWARE	25	75	100	3	0	0	3
12	12PE23	SUPPORT VECTOR MACHINE	25	75	100	3	0	0	3
13	12PE24	OPTIMIZATION TECHNIQUES	25	75	100	3	0	0	3
14	12PE25	NEURAL AND FUZZY SYSTEMS	25	75	100	3	0	0	3
15	12PE26	EVOLUTIONARY COMPUTATION	25	75	100	3	0	0	3
		ELECTIVE IV							
16	12PE27	ADVANCED ELECTRIC DRIVES AND CONTROLS	25	75	100	3	0	0	3
17	12PE28	POWER ELECTRONICS APPLICATIONS TO POWER SYSTEMS	25	75	100	3	0	0	3
18	12PE29	FLEXIBLE AC TRANSMISSION SYSTEMS	25	75	100	3	0	0	3
19	12PE30	ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY IN SYSTEM DESIGN	25	75	100	3	0	0	3
20	12PE31	POWER ELECTRONICS IN WIND AND SOLAR POWER CONVERSION	25	75	100	3	0	0	3
		ELECTIVE V							
21	12PE32	PULSE WIDTH MODULATION FOR POWER CONVERTERS	25	75	100	3	0	0	3
22	12PE33	MODERN DIGITAL SIGNAL PROCESSING	25	75	100	3	0	0	3
23	12PE34	WAVELETS AND APPLICATIONS	25	75	100	3	0	0	3
24	12PE35	RESEARCH METHODOLOGY	25	75	100	3	0	0	3
25	12PE36	COMPUTER NETWORK ENGINEERING	25	75	100	3	0	0	3
		ELECTIVE VI							
26	12PE37	MODEL PREDICTIVE CONTROL	25	75	100	3	0	0	3
27	12PE38	VIRTUAL INSTRUMENTATION	25	75	100	3	0	0	3
28	12PE39	DATA ACQUISITION SYSTEMS	25	75	100	3	0	0	3
29	12PE40	INDUSTRIAL ROBOTICS AND AUTOMATION	25	75	100	3	0	0	3
30	12PE41	VLSI CIRCUITS AND SYSTEMS	25	75	100	3	0	0	3

12PE01 APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERING

(Common to PSE and PED)

L	T	P	C
3	1	0	4

CALCULUS OF VARIATION (09)

Functional - Euler's equation - Variational problems involving one unknown function - Several unknown functions - Functional dependent on higher order derivatives - Several independent variables - Isoperimetric problems.

ADVANCED MATRIX THEORY (09)

Matrix Norms – Jordan Canonical Form – Generalized Eigenvectors – Singular Value Decomposition – Pseudo Inverse – Least Square Approximation – QR Algorithm.

SINGLE VARIABLE OPTIMIZATION (09)

Optimality criteria – Exhaustive search method – Bounding phase method – Interval halving method – Fibonacci search method – Golden section search method – Successive quadratic estimation method – Newton Raphson method – Bisection method – Secant method – Cubic search method – Root finding using optimization techniques.

LINEAR PROGRAMMING (09)

Simplex algorithm - Two phase and Big -M method - Duality theory - Dual simplex method - Transportation and Assignment problems.

NON-LINEAR PROGRAMMING (09)

Formulation of non-linear programming problem – Constrained optimization with Equality constraints – Constrained optimization with inequality constraints – Saddle point problem – Graphical method of non-linear programming problem involving only two variables – Kuhn-Tucker conditions with non-negative constraints.

Lecture : 45 Tutorial : 15 Total : 60 Hrs

Reference Books

1. *Venkataraman M.K, "**Higher Mathematics for Engineering & Science**",National Publishing Company, 2000.*
2. *Kandasamy.P, "**Engineering Mathematics Volume – II**", S.Chand & Co., Third Edition, 2006.*
3. *Gupta P.K. Hira D.S, "**Operations Research**", S.Chand & Co., Third Edition, 2008.*
4. *Veerarajan. T, "**Probability, Statistics & Random Processes**", Tata McGraw Hill, Second Edition, 2002.*
5. *Kalyanmoy Deb, "**Optimization for Engineering Design – Algorithms and Examples**", Prentice Hall of India Pvt. Ltd., 2004.*

12PE02 SYSTEMS THEORY

(Common to PSE and PED)

L	T	P	C
3	0	0	3

STATE VARIABLE REPRESENTATION (09)

Concepts of state, state variables and state model- State model for linear time invariant systems – state space representation using physical, phase and canonical variables – transfer function from state model – Direct cascade parallel decomposition – solution of state equation – state transition matrix

SYSTEM MODELS (09)

Characteristic equation – Eigen values and eigen vectors – Invariance of eigen values – Diagonaliozation – Jordan canonical form – Concept of controllability and observability – Kalman's and Gilbert's tests – Controllable and Observable Phase Variable forms for SISO and MIMO systems – Effect of pole-zero cancellation on controllability and observability – Pole placement by state feedback – Full order and reduced order observers

NON-LINEAR SYSTEMS (09)

Types of non linearity – Phase plane analysis – Singular points – Limit cycles – Construction of phse trajectories – Describing function method – Derivation of describing functions

STABILITY (09)

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-Gradient Method.

ADVANCED CONTROL SYSTEMS (09)

Adaptive Control: Model – Reference Adaptive Control fundamental concepts – Self tuning Control – Robust Control; Parameter perturbations – Design of robust control system – PID controllers – Fuzzy Logic Control – Neutral Network Controller – Genetic Algorithm

Total: 45 Hrs

Reference Books :

1. *Katushiko Ogata, "**Modern Control Engineering**", Pearson Hall of India Private Ltd, New Delhi, III 2 Edition, 2002*
2. *Gopal.M, "**Modern Control System Theory**", New Age International, 2005.*
3. *Roy Choudhury.D, "**Modern Control Systems**", New Age International, 2005*
4. *John J. D'Azzo, Houpis.C.H and Sheldon.S.N, "**Linear Control System Analysis and Design with MATLAB**", Taylor Francis, 2003*
5. *Bubnicki.Z, "**Modern Control Theory**", Springer, 2005.*

12PE03 POWER SEMICONDUCTOR DEVICES AND APPLICATIONS

L	T	P	C
3	0	0	3

OVERVIEW OF POWER SEMICONDUCTOR SWITCHES (09)

Introduction - Diodes, Thyristors, BJTs, JFETs, MOSFETs, GTOs IGBTs, Comparison of these as switching devices, Drive and Protection circuit for these devices – New Semiconductor materials for Power devices.

POWER DIODE AND POWER BJT (09)

Basic structure and I-V & Switching characteristics of Power diode, Schottky diode - Structure and Switching characteristics of Power BJT - Breakdown voltage considerations - Safe operating area - Drive circuits for BJT – Snubber design for Power diode.

THYRISTORS AND GTOs (09)

Basic structures - I-V characteristics - Physics of device operation - Switching characteristics of Thyristors and GTOs – Derive circuits - Snubber circuits for Thyristors and GTOs - Over current protection of GTO.

IGBT AND POWER JFET & MOSFETS (09)

Basic structures - I-V characteristics, physics of device operation - Switching characteristics – Safe operating area of IGBT and Power JFET & MOSFET - Derive circuits and Protection.

APPLICATIONS (09)

Single phase rectifiers and Three phase rectifiers using Diodes and Thyristors, Choppers, Inverters using GTOs-IGBTs and power JFETs & MOSFETs.

Total: 45 hrs

Reference Books :

1. *Mohan. N et al.,"**Power Electronics: Converters, Applications and Design**", John Wiley and Sons, Newyork, Third Edition,2002.*
2. *Kassakian,J.G.et.al.,"**Principles of Power Electronics**", Pearson Education India., 2010.*
3. *Rashid M.H., "**Power Electronics Circuits, Devices and Applications**", Prentice Hall India, Third edition, New Delhi 2004.*
4. *M.D. Singh and K.B.Khanchandani , "**Power Electronics**", Tata McGraw Hill, New Delhi, Second Edition, 2008.*
5. *Donald A.Neamen, "**Semiconductor Physics and Devices**", Tata McGraw Hill, New Delhi, Fourth Edition, 2011.*

12PE04 ANALYSIS OF CONVERTERS

L	T	P	C
3	0	0	3

AC-DC CONVERTER (9)

Introduction- Single and three phase half controlled and fully controlled converters with R-L, R-L-E loads and freewheeling 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.

DC-DC CONVERTER (9)

Introduction-Configurations with Ideal switches – Types of choppers A,B,C,D and E – Control strategies – Analysis of buck, boost, buck-boost and Cuk converters -Steady state operation of PWM controlled choppers – Closed loop control – Time Domain analysis – multi phase configurations using ideal switches-Forced commutated choppers – Resonant and quasi – resonant converters.

AC VOLTAGE CONTROLLERS (9)

Introduction-Static Characteristics of TRIAC- Principle of phase control -Single phase AC voltage regulators with R, & R-L loads – Sequence control of AC regulator – Three phase AC regulator –various configurations – analysis with R and R-L loads.

CYCLOCONVERTERS (09)

Introduction-Practical cycloconverter Circuits – Single phase to single phase, three phase to single phase, three phase to three phase – -Forced commutated cycloconverters– General expression of the output voltage of a three phase cycloconverter – Harmonics– Power factor Control.

CONTROL CIRCUITS (09)

Introduction-Gating circuits for single phase and three phase fully controlled thyristor converters: Gating pulse requirements – Schemes for generating gating pulses . Gating requirements for choppers – A gating circuit for PWM type A chopper.- Control circuit for cycloconverter: Synchronizing circuit – Reference voltage signals – Logic and Triggering circuit – Converter group selection - Firing circuits for three phase AC regulators.

Total : 45 Hrs

Reference Books :

1. *G.K.Dubey, S.R.Doradla., A.Joshi, R.M.K Shinha* ***"Thyristorised Power Controllers"****,New Age International Pvt. Ltd., Delhi, I Edition, Reprint, 2010.*
2. *M.H.Rashid, "****Power Electronics: Circuits, Devices and Application",*** *Pearson, Education of India,2011.*
3. *P.S.Bimbhra, "****Power Electronics', Khanna Publishers"****, Delhi, 4th Edition, 2006.*
4. *M.D.Singh,Kanchandani,* ***"Power Electronics****", Tata McGraw Hill ., Delhi, I Edition, 2008.*
5. *P.C.Sen, "****Power Electronics****",Tata McGraw Hill India Pvt. Ltd., I Edition, 2007.*

12PE05 ANALYSIS OF INVERTERS

L	T	P	C
3	0	0	3

VOLTAGE SOURCE BRIDGE INVERTERS (09)

Basic bridge inverter circuits: Control strategy and output voltage waveforms Single phase bridge inverter load current waveforms and commutation requirements – Modified McMurray half bridge inverter - Modified McMurray full bridge inverter - Single phase & three phase inverters - Modified McMurray Bedford half bridge inverter - Full bridge & three phase bridge inverters using McMurray - Bedford method of commutation - Three phase bridge inverter with DC side commutation.

VOLTAGE CONTROL AND HARMONIC REDUCTION IN INVERTERS (09)

Voltage control: Control of DC Voltage supplied to the inverter - Control of voltage delivered by the inverter - Control of voltage within inverter using time ratio control techniques - Pulse width modulated inverters: Single pulse, Symmetrical multiple pulse, Multiple pulse with selective reduction of harmonics and Sinusoidal pulse width modulation. Implementation of PWM in single phase full / half bridge inverter circuits and three phase bridge inverters. Harmonic reduction: Harmonic elimination and Reduction by PWM - Harmonic reduction using stepped wave inverters - Multiple commutation & transformer connection – Harmonic filters.

CURRENT SOURCE INVERTER (09)

Circuit configurations using ideal switches - Single phase, Three phase CSI, practical CSI - Single phase & Three phase capacitor commutated current source inverter with R,L,RL & LE loads - Modified CSI configurations with commutation through load neutral, with coupled reactor commutation, with chopper commutation.

SERIES INVERTER (09)

Basic series inverter- Idealized approximate analysis of the basic series inverter – Detailed analysis of a basic series inverter - Modified series inverter - Three phase series inverter - Time sharing high frequency inverter - Multilevel inverter : Introduction to multilevel inverter – Types of multilevel inverter – Diode clamped multilevel inverter – Flying capacitor multilevel inverter – Cascaded multilevel inverter – Comparison – Application.

MODERN INVERTERS AND GATING CIRCUITS (09)

Resonant inverters - Series and parallel - Class E series inverter - ZCS and ZVS concepts - Resonant DC link inverters - Gating circuit for single phase complementary commutated inverter - Logic circuit for three phase current source inverter.

Total : 45 Hrs

Reference Books

1. *G.K.Dubey, S.R.Doradla., A.Joshi, R.M.K Shinha, "**Thyristorised Power Controllers**", New Age International Pvt. Ltd., Delhi, I Edition, Reprint, 2010.*
2. *M.H.Rashid, **"Power Electronics: Circuits, Devices and Application"**, Pearson, Education of India,2011.*
3. *P.S.Bimbhra, **"Power Electronics"**, Khanna Publishers, Delhi, 4th Edition, 2006.*
4. *M.D.Singh,Kanchandani, **"Power Electronics"**, Tata McGraw Hill ., Delhi, I Edition, 2008.*
5. *P.C.Sen, **"Power Electronics"**,Tata McGraw Hill India Pvt. Ltd., I Edition, 2007.*

12PE06 SOLID STATE DC DRIVES

L	T	P	C
3	0	0	3

REVIEW OF CONVENTIONAL DC DRIVES (08)

Review of speed – torque characteristics of DC motors- Static Ward Leonard speed control - Methods of braking of series and separately excited dc motors - Different methods of speed control - Models and transfer function of series and separately excited dc motor - Inching and Jogging-Dynamic equations, components of torque-multi quadrant operation.

CONVERTER CONTROL OF DC MOTOR (10)

Single phase converter configurations - Three phase converter configurations for various modes of operation of series and separately excited dc motor - Steady state analysis of three phase converter controlled dc drives - Critical triggering angle - Discontinuous current conduction ,firing circuits- Problems-closed loop control using conventional controllers-dual converter fed dc motor.

CHOPPER CONTROL OF DC MOTORS (09)

Steady state analysis of chopper controlled dc drives - Continuous and discontinuous current conduction - Other chopper circuits - Effects of saturation in dc series motor - CLC and TRC strategies-multi quadrant control-firing circuits-related problems.

DESIGN OF CONVERTER FED DC DRIVES (09)

Speed controlled drive system - Inner current control loop – Linear transfer function model of power converters - Modeling and analysis. Armature current reversal and Field current reversal schemes - Dynamic simulation of speed controlled dc motor drive and applications.

INTELLIGENT CONTROLLERS FOR DC DRIVES (09)

Micro Computer implementation for drives and its reversal - Fuzzy , Neuro and Neuro Fuzzy Controllers.

Total : 45 Hrs

Reference Books

1. *Sen, P.C. "**Thyristor DC Drives**", John Wiley and Sons. Inc., New York, 1981.*
2. *Krishnan.R. "**Electric Motor Drives- Modelling, Analysis and Control**", Pearson Education, First Indian Reprint, 2003.*
3. *Dubey,G.K. "**Power Semiconductor Controlled Drives**", Prentice Hall International, New Jersey, 1989.*
4. *Vedam Subramanyam,"**Electric drives concepts and applications**", Tata McGraw Hill publishing company Ltd., New Delhi, 2002.*
5. *Kaimal M.R., Dass Gupta S. and Hari Sankar M., "**Neuro Fuzzy Control System**", Narosa Publications, New Delhi, 1997.*

12PE07 SOLID STATE AC DRIVES

L	T	P	C
3	0	0	3

PHASE CONTROLLED INDUCTION MOTOR DRIVES (09)

Introduction - AC voltage controller circuits - Torque speed characteristics with phase control – Interaction with load - Steady state computation of load interaction - Speed reversal - Four quadrant control and closed loop operation.

FREQUENCY CONTROLLED INDUCTION MOTOR DRIVES (09)

VSI driven induction motor- CSI driven induction motor - Constant volts/hz control and closed loop control - Constant slip speed control and steady state analysis - Constant air gap flux control - Comparison of VSI and CSI fed drives.

ROTOR RESISTANCE CONTROL AND VECTOR CONTROL (09)

Constant torque operation - Combined stator voltage and rotor resistance control - Principle of vector control - Direct vector control scheme - Indirect vector control scheme - Implementations.

SLIP ENERGY RECOVERY SCHEME (09)

Torque slip characteristics - Power factor consideration - Closed loop control -Harmonic torques - Static Scherbius drive - Torque equations - Applications - Sub synchronous operation.

SYNCHRONOUS MOTOR DRIVES (09)

Vector controlled PM synchronous motor drives - Flux weakening speed control - Torque angle control - Power factor control and self control - Open loop VSI fed drive and its characteristics - Brushless excitation systems.

Total : 45 Hrs

Reference Books

1. *Krishnan.R. '**Electric Motor Drives- Modelling, Analysis and Contro**l', Pearson Education, First Indian Reprint,Delhi,2003.*
2. *Dubey,G.K.'**Power Semiconductor Controlled Drives**',Prentice Hall International, New Jersey, 1989.*
3. *Murphy, J.M.D, Turnbull, F.G. '**Thyristor Control of AC Motors**', Pergamon press, Oxford, First Edition,1988.*

12PE08 SPECIAL MACHINES AND CONTROLLERS

L	T	P	C
3	0	0	3

SYNCHRONOUS RELUCTANCE MOTORS (09)

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

STEPPING MOTORS (09)

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-Applications

SWITCHED RELUTANCE MOTORS (09)

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

PERMANENT MAGNET SYNCHRONOUS MOTORS (09)

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

PERMANENT MAGNET BRUSHLESS DC MOTORS (09)

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

Total : 45 Hrs.

Reference Books

1. *Miller, T.J.E. "**Brushless permanent magnet and reluctance motor drives** ",Clarendon Press, Oxford University, 1989.*
2. *Kenjo, T, "**Stepping motors and their microprocessor control** ", Clarendon Press, Oxford University, Second Edition, 1994.*
3. *Kenjo, T and Naganori, S "**Permanent Magnet and brushless DC motors** ", Clarendon Press, Oxford University, 1990.*
4. *Kenjo, T., **"Power Electronics for the microprocessor Age"**, Oxford University Press, 1990.*
5. *B.K. Bose, **"Modern Power Electronics & AC drives"**, Prentice Hall Publisher, 2002.*
6. *R.Krishnan, **"Electric Motor Drives – Modeling, Analysis and Control"**, Prentice-Hall of India Pvt. Ltd., New Delhi, 2010*
7. *Venkataratnam,**"Special Electrical Machines"**, Tayler and Francis, 2009.*

12PE09 POWER ELECTRONICS SIMULATION LAB

L	T	P	C
0	0	3	2

1. a) Single phase half wave controlled rectifier(R & RL Load)
   b) Single phase full wave controlled rectifier(R & RL Load)
2. a) Three phase semi converter (R & RL Load)
   b) Three phase full converter
3. a) Open loop control of single phase semi converter fed dc drive
   b) Closed loop control of single phase semi converter fed dc drive
4. a) Open loop control of chopper fed dc drive(CCM & DCM)
   b) Closed loop control of chopper fed dc drive with pi and fuzzy controller
5. a) Single phase full bridge inverter using PWM techniques
   b) Three phase inverter (120^0 mode & 180^0 mode)
6. Three phase inverter fed induction motor drive
7. Cascaded multilevel inverter
8. a) Dual converter
   b) Single phase cyclo-converter
9. Single phase ac voltage regulator(R & RL load)
10. Four quadrant operation of three-phase induction motor
11. Micro controller based speed control of Converter/Chopper fed DC motor.
12. Micro controller based speed control of VSI fed three-phase induction motor.
13. Micro controller based speed control of Stepper motor.

Total : 45 Hrs.

Reference Books :

1. *Raymond Ramshaw, Derek Schuuman, "**Pspice Simulation of Power Electronics Circuit: an introductory guide**", Chapman & Hall, 1997.*
2. *M.H.Rashid, "**Power Electronics Handbook devices, circuit and applications**", Third Edition, 2010.*
3. *P.S. Bimbhra, "**Power Electronics**", Khanna publishers, 1999.*

12PE12 NON LINEAR SYSTEMS

(Common to PSE and PED)

L	T	P	C
3	0	0	3

INTRODUCTION TO NON LINEAR SYSTEMS (9)

Introduction, Characteristics of Non linear systems, Jump resonance, Sub-harmonic oscillations, Limit cycles, Frequency entertainment quenching, Non-linearities - inherent and intentional.

PHASE PLANE ANALYSIS (9)

Phase plane analysis, Singular points, sketching of phase portraits, Limit cycles, nonlinear conservative system with nonlinear damping. Effect of non-linearities on the step response of the position control and relay systems.

DESCRIBING FUNCTION ANALYSIS (9)

Describing function techniques - Describing functions of nonlinear characteristics, Expression for the functions, Accuracy of describing function methods, Describing functions for multiple non linearities, Evaluation of the gain function for analytically and graphically defined characteristics.

CONCEPTS OF STABILITY (9)

Experimental determination of gain functions, Condition for stability, stability of oscillations, Stability of systems with multiple non-linearities, Closed loop frequency response, Transient response, Dual input describing functions.

STABILITY ANALYSIS (9)

Lyapunov's and Popov's stability criteria, Linearisation and stability in the small and large sense, Second method of Lyapunov, Variable gradient methods, Lure's problem, Popov's stability Theorem.

Total : 45Hrs

Reference Books

1. *H.Khalil,* ***"Non linear Systems"****, Macmillan Pub. Company, New york, 1992 .*
2. *I.J.Nagrath and M.Gopal,* ***"Control System Engineering"****, John Wiley Publishing Ltd., 1993.*
3. *Ogata,* ***"Modern Control Engineering"****, Prentice Hall India, 1991.*

12PE13 HIGH VOLTAGE DC TRANSMISSION SYSTEMS

(Common to PSE and PED)

L	T	P	C
3	0	0	3

DC POWER TRANSMISSION TECHNOLOGY (09)

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.

ANALYSIS OF HVDC CONVERTERS (09)

Pulse number – Choice of converter configuration – Simplified analysis of Graetz circuits – Converter bridge characteristics – Characteristics of twelve-pulse converter – Detailed analysis of converters.

CONVERTER AND HVDC SYSTEM CONTROL (09)

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 – Higher level controllers – Telecommunication requirements.

HARMONICS AND FILTERS (09)

Introduction – Generation of harmonics – Design of AC filters – DC filters – Carrier frequency and RI noise.

SIMULATION OF HVDC SYSTEMS (09)

Introduction – System simulation: Philosophy and tools – HVDC system simulation – Modelling of HVDC systems for Digital Dynamics Simulation.

Total : 45 Hrs

Reference Books

1. *Padiyar .K .R. , '**HVDC Power Transmission Sy**stems ', New age international(P) Ltd, New Delhi, 2002.*
2. *Edward Wilson Kimbark , '**Direct Current Transmission'**, Vol 1 , Wiley Interscience, Newyork, London, Sydney, 1971.*
3. *Rakosh Das Begamudre , '**Extra High Voltage AC Transmission Engineering'** ,Wiley Eastern Ltd, New Delhi, 2006.*
4. *Arrillaga .J, '**High Voltage Direct Current Transmission'**, Peter Pregrinus London, Second Edition, 1998.*
5. *Adamson .C and Hingorani N.G., '**High Voltage Direct Current Power Transmission**", Garraway Ltd., London, 1967.*
6. *Kundur.P, "**Power system stability and control**", McGraw Hill, 1994.*
7. *www.abb.se/pow/hvdc.htm*
8. *www.pwrgen.westinghouse.com/energy/facts.htm*
9. *www.hvdc.ca*

12PE14 MODELING AND ANALYSIS OF ELECTRICAL MACHINES

(Common to PSE and PED)

L	T	P	C
3	0	0	3

PRINCIPLES OF ELECTROMAGNETIC ENERGY CONVERSION (09)

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.

REFERENCE FRAME THEORY (09)

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.

DC MACHINES (09)

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

INDUCTION MACHINES (09)

Voltage and toque 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 – dynamic performance for three phase fault – computer simulation in arbitrary reference frame.

SYNCHRONOUS MACHINES (09)

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 : 45Hrs

Reference Books

1. *Paul C.Krause, Oleg Wasyzczuk, Scott S, Sudhoff, "**Analysis of Electric Machinery and Drive Systems**", IEEE Press, Second Edition, 2002.*
2. *Krishnan.R, "**Electric Motor Drives, Modeling, Analysis and Control**", Prentice Hall of India, 2002*
3. *Samuel Seely, "**Eletromechanical Energy Conversion**", Tata McGraw Hill Publishing Co, 1962.*
4. *Fitzgerald.A.E, Charles Kingsley, Jr, and Stephan D, Umanx, "**Electric Machinery**", Tata McGraw Hill, 6th Edition, 2002.*

12PE15 COMPUTER AIDED DESIGN OF ELECTRICAL MACHINES

L	T	P	C
3	0	0	3

DESIGN PROCEDURE (09)

Conventional design procedures-Limitations-Main dimensions and Field system of DC and AC machines-problems.

MATHEMATICAL FORMULATIONS OF FIELD PROBLEMS (10)

Development of torque/force – Electromagnetic Field Equations – Magnetic Vector/ Scalar potential - Electrical Vector/ Scalar potential – Stored energy in field problems – Inductance – Laplace and Poisson's equations –Maxwell equations – problems.

PHILOSOPHY OF FEM (09)

Differential / Integral equations – Numerical methods - Finite Difference method – Finite Element method – Moment method - Energy minimization – Variational method – 2D field problems –Discrimination – Shape functions – Stiffness matrix.

CAD PACKAGES (09)

Energy functional – Principle of energy conversion - Elements of a CAD System – Preprocessing – Modeling –Simple iterative methods - Newton Raphson and Gauss Seidal Methods - Meshing – Materials properties - Boundary Conditions – Solution techniques – Post processing and Optimization.

APPLICATIONS (08)

Design of Solenoid Actuator – Switched reluctance motor - Induction motor - Stepper motor.

Total : 45 Hrs

Reference Books

1. *Silvester and Ferrari, "**Finite Elements for Electrical Engineers**", Cambridge University Press, New York, Third Edition, 1996.*
2. *Trowbridge C.W, "**An Introduction to Computer Aided Electromagnetic Analysis**", Vector Fields Ltd., Oxford, 1990.*
3. *Hoole S.R.H, "**Computer Aided Analysis and Design of Electromagnetic Devices**", Elsevier Science Publishing Co., New York, 1989.*
4. *Sawhney A.K, "**A Course in Electrical Machine Design**", Dhanpat Rai & Sons, New Delhi, 1996.*
5. *Sawhney A.K, Chakrabarti. A, "**A Course in Electrical Machine Design**", Dhanpat Rai, Sixth Edition, 2010.*

12PE16 MODERN CONVERTERS AND CONTROL TECHNIQUES

L	T	P	C
3	0	0	3

CARRIER-BASED PULSE WIDTH MODULATION INVERTERS (09)

Overview of Three phase Inverters-Performance indices-Harmonic spectrum analysis-Modelling of three phase Inverters-Carrier-Based Pulse Width Modulation Algorithms-Carrier-Based PWM Algorithms with Improved Reference-PWM Used within Volt/Hertz Drives-Implementation of Harmonic Reduction with carrier PWM-Limits of Operation.

VECTORIAL PWM FOR INVERTERS AND PROTECTION FOR CONVERTERS (09)

Review of Space Vector Theory-Vectorial Analysis of the Three-Phase Inverter-SVM Theory: Derivation of the Time Intervals Associated to the Active and Zero States by Averaging-Adaptive SVM:DC Ripple Compensation-Link to Vector Control: Different Forms and Expressions of Time Interval Equations in the(d,q) Coordinate System-Definition of the Switching Reference Function- Definition of the Switching Sequence- Comparison between Different Vectorial PWM—Over modulation for SVM-Volt/Hertz Control of PWM Inverters - Practical Aspects in Building Three-Phase Power Converters.

PWM ALGORITHMS, CURRENT CONTROL AND COMPONENENT MINIMISATION (10)

Analog Pulse Width Modulation Controllers-Mixed-Mode Controller ICs-Digital Structures with Counters: FPGA Implementation—Software Implementation in Low cost Microcontrollers -Microcontrollers with Power Converter Interfaces-Motor Control Co-Processors-Using the Event Manager within Texas Instrument's DSPs- Practical Aspects of Implementing Closed Loop Current control- Component-Minimized Three-Phase Power Converters.

GRID INTERFACE AND PARALLEL POWER CONVERTERS (09)

Particularities, control Objectives and Active Power Control-PWM in the Control System- Closed loop Current Control Methods-Grid Synchronization-Comparison between Converters Built of High Power Devices and Solutions based on Multiple Parallel Lower-Power Devices-Hardware Constraints in Paralleling IGBTs-Gate Control Designs for Equal Current Sharing-Advantages and Disadvantages of Paralleling Inverter Legs -Interleaved operation of power converters-Circulating Currents-Selection of the PWM Algorithm-System Controller.

IMPLEMENTATION OF MODULATION CONTROLLER (08)

Elements of PWM converter system-Hardware implementation of the PWM process-Continuing developments in Modulation : Random Pulse width Modulation –PWM rectifier with voltage unbalance- common Mode Elimination-four Phase leg Inverter Modulation-Effect of Minimum Pulse width-PWM Dead-time compensation.

Total: 45 Hrs

Reference Books

1. *Dorin O. Neacsu," **Power Switching Converters**", CRC Press,"Taylor & Francis, 2006.*
2. *Grahame Holmes D. and Thomas A. Lipo, "**Pulse width Modulation for Power Converters**", IEEE Press series on Power Engineering, Wiley-Interscience, John Wiley&Sons,Inc., 2003.*

12PE17 MICROCONTROLLER BASED SYSTEM DESIGN

(Common to PSE and, PED)

L	T	P	C
3	0	0	3

PIC 16C7X MICRO CONTROLLER –FRAME WORK (09)

Architecture- Program memory considerations-register file structure- CPU registers -Addressing modes-Instruction set -simple programs.

REAL TIME CONTROL (09)

Interrupt structure - Interrupt logic-Interrupt service routine - Interrupt constraints - Critical regions – Shortening an interrupt handler -Timers -0-1-2 and uses – Timer External event counter -PWM outputs.

PERIPHERALS OF PIC MICROCONTROLLER (09)

I^2C bus for peripherals chip access- I^2C Bus operation A/D converters- overview-ADC characteristics ADC use - UART wave forms and baud rate accuracy – UART data handling circuitry - UART uses.

INPUT/OUTPUT PORT EXPANSIONS (09)

Synchronous serial port module - serial peripherals interface- output port expansion-input port expansion-LCD Display-motor control.

FRONT PANEL I/O (09)

Overview - Soft keys-state machines and key switches-Display of variable strings-Display of constant strings-Special features – configuration word- oscillator configuration – low power operation.

Total : 45 Hrs

Reference Books

1. *John B.Peatman, "**Design with PIC Microcontroller**", Pearson Education, Asia 2004.*

2. *Myke Predko, "**Programming and Customizing the PIC Microcontroller**", Tata McGraw Hill, Third Edition.*

12PE18 DIGITAL SIGNAL PROCESSING AND CONTROL

L	T	P	C
3	0	0	3

DISCRETE SIGNAL LINEAR SYSTEMS (09)

Discrete Linear systems – Time invariance –Causality, Stability, Difference Equations-Transfer functions of linear discrete systems – Impulse, step and frequency response – linear and circular convolution- Recursive and non-recursive filters – Digital filter realization – Direct, Canonic, Cascade, Parallel and ladder realizations.

TRANSFORMATIONS IN DSP (08)

Review of Continuous Fourier series- Transform- Discrete Fourier Transform – Properties – IDFT- Introduction to Radix- 2 FFT – Properties – Decimation in time – Decimation in frequency – Computation of IDFT using DFT.

DIGITAL FILTERS (10)

Approximation of analog filters – Butterworth & Chebychev – Properties of IIR filter – IIR filter design- Bilinear transformation and Impulse invariance method – Digital transformation – characteristic of FIR filter - frequency response of linear phase FIR filter Design of FIR filter – Fourier series method–window function –Rectangular, Kaiser, Bartlet.

HARDWARE FOR DIGITAL SIGNAL PRCESSING (09)

Computer Architecture for signal processing : Harvared Architecture – Pipelining – Hardware MAC unit- special instructions to DSP – Architecture of TMS320C5X – replication – On chip memory. Assembly language Instructions of TMS320C5X : Syntax – Addressing modes- load/store instructions – Arithmetic Instructions – program control Instruction – peripheral control – instructions- pipelining.

APPLICATION OF DSP'S IN CONTROL SYSTEM (09)

Issue in Implementation of DSP algorithms on general purpose and special purpose digital signal processors: – FIR digital filtering – IIR digital filtering- FFT processing. PID controllers - implementation issues – motor control disk drive servo control – Stabilization/ pointing systems (elementary treatment only).

Total : 45 Hrs

Reference Books

1. *John.G.Proakis, Dimitrias.G. and Manolakis. "**DSP principles Algorithms and applications**", Prentice Hall of India – Fourth Edition, 2001.*
2. *Emmanuel C.Ifeachor, University of Plymouth. Barrie.W.Jervis, Sheffield Hallam University, "**Digital Signal Processing. A Practical Approach**", Pearson Education, II Edition, 2002.*
3. *Sanjit K.Mitra, "**Digital Signal Processing A computer Based approach**" TataMcGrawHill, Fourth Edition, 2010.*
4. *Farzad Nekoogar, Gene moriarty. "**Digital Control Using Digital Signal Processing**" P.H.International Inc. New Jersey.1999.*

12PE19 VHDL BASED DIGITAL SYSTEM DESIGN

L	T	P	C
3	0	0	3

BASIC MODELLING CONSTRUCTS (09)

Design process flow – Software tools – Hardware Description Languages – VHDL: Data types – Operators – Entities and architecture – Component declaration – Component instantiation – Concurrent signal assignment – Sequential signal assignment – Selected signal assignment – Concurrent statements – Sequential statements – Behavioral data flow and structural modelling.

SUB PROGRAMMES AND FILE HANDLING (09)

Procedures - Functions – Overloading – Packages - Use clause – Aliases - Generic constants - Generic statement - File declarations – Reading - Writing –Explicit open and close operations – File parameters in sub programmes.

PLDs AND FIELD PROGRAMMABLE GATE ARRAYS (09)

Basic concepts – Programming technologies – Programmable Logic Element – Programmable Logic Array – Programmable Array Logic – Structure of standard PLDs – Complex PLDs - Types of FPGA – Logic Cell Array – CLBs – Input/ Output Blocks – Programmable Interconnection Points – Standard FPGA structures – Design Examples.

SYSTEM DESIGN USING PLDs AND FPGAs (09)

Design of combinational and sequential circuits using PLDs and FPGAs - Programming PAL devices – Design of state machines using Algorithmic State Machines (ASM) chart as a design tool.

VERILOG HDL (09)

Modules and their instantiations – Net and register data types – Operators – initial and always blocks – Assign statement – Sequential statements – Blocking and nonblocking procedural assignments – Tasks – Functions – Systems tasks and functions – Synthesis issues – Tristate and latch interference – File I/O – Test benches.

Total : 45 Hrs

Reference Books

1. *Bhaskar, "**A VHDL primer**", PHI Learning, III Edition,2009.*
2. *Navabi.Z "**VHDL : Analysis and Modelling of Digital Systems**" , McGraw Hill,I Edition, 2002.*
3. *Robert Dueck,"**Digital Design with CPLD applications and VHDL**", Delmar Thomson II Edition Learning, USA, I Edition, Reprint 2011.*
4. *Peter J Ashenden, "**The Designer's Guide to VHDL**"', Harcott India, III Edition,2008.*
5. *Richard C Dorf and V Oldfield, "**Field Programmable Gate Arrays : reconfigurable logic for rapid prototyping and implementation of digital systems**", John Wiley, 1995.*

12PE20 REAL TIME EMBEDDED SYSTEMS

L	T	P	C
3	0	0	3

FUNDAMENTALS AND BUS PROTOCOLS (09)

Classification of Embedded Systems - Embedded System on Chip - Structural Units in a Processor - Processor Selection - Memory Selection. Allocation of Memory to Segment and Block Memory Map of a System - Serial Communication using I^2C Bus and CAN – Parallel Communication using ISA and PCI busses.

PROGRAMMING MODELLING CONCEPTS AND UML (09)

Data Flow Graph – Control Data Flow Graph – Finite State Machine (FSM) Model – Petri Net Model – Issues in Multiprocessor Systems – Synchronous Data Flow Graph(SDFG) Model – Homogeneous SDFG Model – Acrylic Precedence Expansion Graph (APEG) Model – Real time Programming Issues during Software Development – Unified Modeling Language (UML) Basic Elements – UML diagrams.

INTER-TASK COMMUNICATION (09)

Process, Task and Thread – Distinctions between Functions, ISRs and Tasks - Shared Data Problem and its Solutions – Use of Semaphores – Priority Inversion Problem and Deadlock – Semaphore Flag as Resource Key – Message Queues – Mailboxes – Pipes - Virtual Sockets - RPCs.

REAL TIME OPERATING SYSTEMS (09)

OS Services Goals – Structures – Kernel - Process Management – Memory Management - Device Management – File System Organisation and Implementation – Necessity and otherwise in Embedded Systems - Schedule Management for Multiple Tasks – Scheduling of Multiple Tasks – Handling of Interrupt Source Call - Cooperative Round Robin Scheduling using a Circular Queue – Cooperative Scheduling of Ready task using an Ordered List – Cyclic Scheduling with Time slicing – Preemptive Scheduling - Critical Section service by Preemptive Scheduler – Fixed Real Time Scheduling – Precedence Assignment .

HARDWARE SOFTWARE CO-DESIGN AND ARM PROCESSOR (09)

Embedded System Project Management – Design Cycle in the Development Phase - In Circuit Emulator – Logic Analyzer - Integrated Development Environment – Software Hardware Tradeoff – Performance Modeling – Porting Issues of OS in an Embedded Platform – Architecture and Instruction Set of ARM7 processor (Qualitative Treatment only).

Total : 45 Hrs

Reference Books

1. *Raj Kamal, "**Embedded Systems**", Tata McGraw Hill, Second Edition, 2008.*
2. *Frank Vahid and Tony Givargis, "**Embedded System Design – A Unified Hardware/Software Introduction**", John Wiley & Sons Inc., 2002.*
3. *David E. Simon, "**An Embedded Software Primer**", Addison Wesley Longman, Inc., USA, 1999. (India Reprint 2000).*
4. *Jane W.S. Liu, "**Real Time Systems**", Pearson Education, 2000.*
5. *Balarin F. et al., "**Hardware – Software Co-Design of Embedded Systems: The Polis Approach**", Norwell, MA, Kluwer Academic Publisher, 2003.*

12PE21 SIMULATION OF POWER ELECTRONIC SYSTEMS

L	T	P	C
3	0	0	3

INTRODUCTION (09)

Need for simulation - Challenges in simulation - Classification of simulation programs -Overview of PSpice, MATLAB and SIMULINK. Mathematical Modelling of Power Electronic Systems: Static and dynamic models of power electronic switches - Static and dynamic equations and state space representation of Power Electronic systems.

PSPICE (09)

File formats - Description of circuit elements - Circuit description - Output variables -Dot commands - SPICE models of Diode, Thyristors, Triac, BJT, Power MOSFET, IGBT and Power S-Functions - Converting S-Functions to blocks.

MATLAB AND SIMULINK (09)

MATLAB – Intro Variables – Matrix representation and operation, Trigonometric functions, Logical relations, Exponential Complex Numbers – m file – Function – For loop – While – If else. Graphics – 2D Plots. SIMULINK: Intro – Basic Block – Sources and Sinks model analysis using SIMULINK - S-functions - converting S-functions to blocks.

INTRODUCTION TO PSIM (09)

General Information – Power Circuit Components – Control Circuit & Other Components– Analysis specification – Circuit Schematic Design – Waveform Processing – Error and Warning messages.

SIMULATION USING PSPICE, PSIM, MATLAB AND SIMULINK (09)

Diode rectifiers - controlled rectifiers - AC voltage controllers - DC choppers – PWM inverters - voltage source and current source inverters - Resonant pulse inverters – Zero current switching and zero voltage switching inverters.

Total : 45 Hrs

Reference Books

1. *Rashid, M.H., "**SPICE for Power Electronics and Electric Power**", CRC Press, 2nd Edition, 2006.*
2. *Ned Mohan, "**Power Electronics, Computer Simulation Analysis and Education using PSPICE**", Minnesota Power Electronics Research and Education, USA, 1992.*
3. *Chee-Mun-Ong, "**Dynamic simulation of Electric Machinery using MATLAB/SIMULINK**", Prentice Hall Private Limited, New Jersey, 1998.*
4. *"**The PSPICE User's Guide**", Microsim Corporation, California,1996.*
5. *"**The SIMULINK User's Guide**", Math works Inc, 1994.*
6. *"**PSIM User's Guide**", Powersim Inc., 2006.*

12PE22 CONTROL SYSTEM SOFTWARE

(Common to PSE and PED)

L	T	P	C
3	0	0	3

MATLAB BASICS (09)

Introduction - Matrices and Vectors - Matrix and Array operations - Build in functions - Saving and loading data - Script files - Function files - Language specific features.

MATLAB APPLICATIONS AND GRAPHICS (09)

Applications in linear algebra, Curve fitting and interpolation, Data analysis and statistics - Ordinary differential equations and nonlinear algebraic equations - Basic 2-D plots-multiple graphs layout - Handle graphics.

SIMULINK MODELS (09)

Starting simulink - Selecting objects - Blocks - Connecting blocks - Working with signals – Annotations - Working with data types - Creating subsystems.

SIMULATION (09)

Running a simulation with menu commands - Simulation parameter - Dialogue box - Viewing output trajectories - Equilibrium point determination - Running a simulation from command line.

MATLAB TOOLBOXES (09)

Control system toolbox: Linear models - MIMO models - Interconnecting linear models - Continuous/Discrete conversions - LTI viewer - Functions for time and frequency response - Simulink LTI viewer - Principles of symbolic math toolbox.

Total : 45 Hrs

Reference Books

1. *Rudra Pratap, "**Getting Started with MATLAB 7**", Oxford University Press, 2009.*
2. *Duane C. Hanselman, and Bruce Littlefield , "**Mastering Matlab**", Prentice Hall, 2012.*
3. ***Simulink Manual** , The Mathworks Inc.,2000, www.mathworks.com.*
4. ***Control System Toolbox Manual** , The Mathworks Inc.,2000, www. mathworks.com*

12PE23 SUPPORT VECTOR MACHINE

(Common to PSE and PED)

L	T	P	C
3	0	0	3

LEARNING AND SOFT COMPUTING (09)

Examples of Applications in Diverse Fields –Basic tools of soft computing: Neural Networks, Fuzzy Logic Systems, and Support vector machines –Basic mathematics of soft computing – Learning and statistical approaches to Regression and classification.

GENERALIZATION AND OPTIMIZATION THEORY (09)

Learning from examples and generalization-Statistical learning theory – Empirical Risk minimization –Key theorem-VC dimension-Structural Risk minimization.

SUPPORT VECTOR MACHINE (09)

Introduction-Optimal hyper plane for linearly separable classes –Optimal hyper plane for non linear separable classes – Kernel trick and mercer condition-Non linear SVM classifier .

KERNEL INDUCED FEATURE SPACE (09)

Learning in Feature space-The imlicit mapping in feature space –Making Kernels and Gaussian process –PCA.

APPLICATION OF SPM (09)

Principles of pattern recognition-support vector machine for pattern recognition-Non linear regression-identification of process using SVM-Fault diagnosis using SVM-Fault diagnosis using SVM-Modeling and control using Hybrid Intelligent systems.

Reference Books

1. *Nello Cristianini And John Shave –Taylor,* ***"An Introduction To Support Vector Machines And Other kernel based learning methods****",Springer.*
2. *Vladmir N.Vapnik, "****The Nature of statistical learning theory",*** *2nd edition,Springer 2000.*
3. *Bernhard Schlkopf, Alexander J .Smola* ***"Learning with Kernels : Support vector machines, Regularization, Optimization and Beyond (Adaptive computation and machine learning)****", Springer.*
4. *Vojislav keeman',****Learning and soft computing: Support Vector machines ,Neural Networks and Fuzzy Logic model's****, Springer.*
5. *T.Hastie, R.Tibshirani, Friedman,* ***"The Elements of Statistical Learning"****, Springer.*
6. *Satish Kumar,* ***"Neural Network – A classroom approach"****, Tata MCGraw Hill,2004.*
7. *Simon Haykin,* ***"Neural Networks A Comprehensive Foundation"*** *,2nd Edition, Prentice Hall of India.*
9. *Richard O.Duda, Peter E.Hart and David G.Stork,* ***"Pattern classification"****, 2nd Edition ,Wiley Publication.*

12PE24 OPTIMIZATION TECHNIQUES

L	T	P	C
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CLASSICAL OPTIMIZATION (09)

Single variable optimization - Multivariable optimization with no constraints: Semi definite case, Saddle point - Multivariable optimization with Equality constraints: Solution by direct substitution, Solution by the method of constrained variation, Solution by the method of Lagrange Multipliers - Multivariable optimization with Inequality constraints: Kuhn-Tucker conditions, constraint qualification.

SIMPLEX METHOD (09)

Standard form of a Linear programming problem-Geometry of linear programming problems - Definitions and theorems -Solution of a system of linear simultaneous equations - Pivotal reduction of a general system of equations-Motivation of the simplex method - Simplex algorithm - Revised simplex method.

UNCONSTRAINED & CONSTRAINED OPTIMIZATION TECHNIQUES (09)

Unconstrained optimization techniques: Gradient of a function -Steepest descent (Cauchy) method - Newton's method - Marquardt method -Quasi-Newton methods – Broydon – Fletcher – Goldfarb - Sanno method.Constrained optimization techniques: Characteristics of a constrained problem-Generalized reduced gradient method - Sequential quadratic programming-Augmented Lagrange Multiplier method - Checking convergence of constrained optimization problems.

GENETIC ALGORITHMS (09)

Working principles - Differences between GAs and traditional methods-Similarities between GAs and traditional methods - GAs for constrained optimization-Other GAs operators - Real-coded GAs - Advanced GAs - Simulated annealing.

MATLAB AND OPTIMIZATION TOOLBOX (09)

Matlab Basics: Introduction - Matrices and vectors - Matrix and array operations - Built-in functions - Saving and loading data - Script files - Function files.Optimization Toolbox: Linear least squares with linearity constraints - Nonlinear curve fitting via least square with bounds - Linear programming - Quadratic programming - Nonlinear zero finding.

Total : 45 Hrs.

Reference Books

1. *Singiresu S.Rao, "**Engineering Optimization**", 4th Edition,John Wiley & Sons, 2009.*
2. *Kalyanmoy Deb, "**Optimization For Engineering Design: Algorithm and Examples**", Prentice Hall of India,learning 2009. New Delhi, 2000.*
3. *Rudra Pratap, "**Getting Started with MATLAB 7**", Oxford University Press, 2009.*
4. *"**Optimization Toolbox Manual**", The Mathworks Inc., 2000, www.mathworks.com.*

12PE25 NEURAL AND FUZZY SYSTEMS

L	T	P	C
3	0	0	3

FUZZY LOGIC (09)

Introduction - Fuzzy sets – fuzzy relations – Fuzzification and Defuzzification methods.

FUZZY ARITHMETIC (09)

Fuzzy Arithmetic, vectors, extension principle – Fuzzy rule based systems – Linguistic hedges.

PATTERN CLASSIFICATION NETWORKS (09)

Hebb Net – Perceptron – Adaline - LMS learning rule – Madaline – MR-II learning algorithm - Back propagation network.

PATTERN ASSOCIATION NETWORKS (09)

Auto-associative, Hetero-associative and Iterative associative networks – Bi-directional associative memory – Hopfield memory - Boltzman machine – Learning – Counter propagation network – Training – ART - Cognitron.

CONTROL APPLICATIONS (09)

Schemes of neural network control –Applications – Case studies. Structure of Fuzzy logic controller – Applications – Case studies.

Total : 45 Hrs.

Reference Books

1. *J.A.Freeman And B.M.Skapura, **"Neural Networks, Algorithms Applications And Programming Techniques", Pearson Wesley, 1990.***
2. *Laurene Fausett, "**Fundamentals of Neural Networks: Architecture, Algorithms and Applications**", Prentice Hall, 1994.*
3. *Timothy J. Ross, "**Fuzzy Logic with Engineering Applications**", John Wiley & Sons, 2009.*
4. *Driankov D. et.al., "**Introduction to Fuzzy Control**", Narosa Publishing House, New Delhi Reprint 2001.*
5. *Klir,G.J. St.Clair and Boyuan, "**Fuzzy Set Theory – Foundations and Applications**", Prentice Hall International, New Jersey, 1997.*
6. *Zimmermann. H.J., "**Fuzzy Set Theory and its Applications**", IV Edition, Springer, 2001.*

12PE26 EVOLUTIONARY COMPUTATION

L	T	P	C
3	0	0	3

INTRODUCTION (09)

Introduction to optimization – Concept of system and state – Performance measure – Constraints – Conditions for optimality – Linear and nonlinear optimization techniques – Stochastic optimization. Introduction to evolutionary computing – Comparison with traditional optimization techniques

GENETIC ALGORITHMS (GA) (09)

GA simulation – Schema processing – Data structures – reproduction – Crossover – Mutation – Fitness scaling – Constrained genetic algorithms- Penalty functions. Classification of GA - Simple GA – Compact GA – Orthogonal GA – Problems with GA – Genetic drift – Deception – Real-time and on-line issues – Algorithmic implementation of GA.

GENETIC SEARCH TECHNIQUES **(09)**

Classes of search techniques – GA cycle – Distributed, parallel, structured GA, Dominance, Diploidy, Abeyance – Selection methods – Recombination – Discrete, real valued, binary valued – Single and multi-point crossover – Population models – Multi-objective optimization.

APPLICATIONS OF GA AND PSO (09)

GA in optimization of discrete and continuous systems – GA in pattern recognition – GA based machine learning – GA in signal processing - GA in computer communication. Particle Swarm Optimization (PSO) – Background, operation and basic flow of PSO - Applications of PSO - Comparison between PSO and GA.

ANT COLONY OPTIMIZATION (09)

Ant colony optimization - Biological inspiration – similarities and differences between real ants and artificial ants – characteristics, algorithms and applications of ant colony optimization.

Total : 45 Hrs.

Reference Books

1. *Kalamoy Deb,"**Optimization for Engineering Design: algorithms and examples"**, Prentice Hall of India Ltd, 2004.*
2. *Pierre. D.A., "**Optimization Theory with Applications**", Courier Dover Publications, 1987.*
3. *Rao S.S., "**Optimization Theory and Applications**", Halsted Press, II edition, 1984.*
4. *David E. Goldberg, "**Genetic Algorithms in Search, Optimization and Machine Learning**", International Student Edition , Addison Wesley, 2007.*
5. *S.N.Sivanandam, S.N.Deepa, " **Introduction of Genetic Algorithms**" Springer, Newyork, 2010.*
6. *IEEE Transactions on Evolutionary Computing.*

12PE27 ADVANCED ELECTRIC DRIVES AND CONTROLS

(Common to PSE and PED)

L	T	P	C
3	0	0	3

INTRODUCTION (09)

Need for advanced controls - Principle factor affecting the choice of drive – Parameter identification techniques for electric motors – Electromagnetic compatibility of electric drives – Different options for an adjustable speed electric drive – Simulation of electrical drives – Advanced control strategies for electrical drives – DSP based control of electric drives.

DSP CONTROLLERS AND INSTRUCTION SET (09)

TMS 320 family overview – 320 C24X Series of DSP controllers – Architecture overview – C24X CPU internal bus structure – Memory – Central processing unit – Memory and I/O spaces – Overview of Memory and I/O spaces – Program control –Address modes – System configuration and interrupts – Clocks and low power modes –Digital input/ output (I/O). Instruction set: Assembly language instructions – Instruction set summary – Instruction description – Accumulator, arithmetic and logic instructions – Auxiliary register and data page pointer instructions – TREG, PREG, and Multiply instructions – Branch instructions – Control instructions – I/O and memory instructions.

PWM INVETER CONTROL (09)

Inverter – Operation principle – Inverter switching – Unipolar – Bipolar – Inverter deadtime– inverter modulation – Different types – Sine Triangle – Analysis of Sine Triangle Modulation – Trapezoidal Modulation – Third harmonic Modulation – Analysis of Third Harmonic Modulation – Output filter requirement for different PWM techniques.

SPACE VECTOR MODULATION (09)

Concept of a Space Vector – dq0 Components for Three-phase sine wave source/1evel –dq0 Components for Voltage Source Inverter (VSI) operated in Square Wave Mode –Synchronously rotating reference frame – Space Vector Modulation (SVM) – Principle –SVM compared to regular sampled PWM Phase Lag reference for SVM – Naturally sampled SVM – Analytical solution for SVM – Harmonic losses for SVM – Placement of Zero Space Vector – Discontinuous Modulation – Phase Lag reference for discontinuous PWM.

NEURAL NETWORK AND FUZZY CONTROLLERS (09)

Current and speed control of Induction Motor – Current control algorithm – Sensorless motion control strategy – Induction Motor Controller using VHDL design. Fuzzy Logic Control of a Synchronous Generator – System representation – VHDL Modelling –FPGA implementation.

Total : 45 Hrs.

Reference Books

1. *Bimal K. Bose, "**Power Electronics and Variable Frequency Drives – Technology and Applications**", IEEE Press, 1997.*
2. *Grafame Holmes. D and Thomas A. Lipo, "**Pulse Width Modulation for Power Converters – Principles and Practice**", IEEE Press, 2003.*
3. *Peter Vas, "**Vector Control of AC Machines**", Oxford University Press, 1990.*
4. *Hamid A. Toliyat and Steven G.Campbell, "**DSP based Electromechanical Motion Control**", CRC Press 2004.*
5. *Ned Mohan, "**Advanced Electric Drives: Analysis, Control and Modelling using SIMULINK**", John Wiley & Sons Ltd., 2001.*

12PE28 POWER ELECTRONICS APPLICATIONS TO POWER SYSTEMS

(Common to PSE and PED)

L	T	P	C
3	0	0	3

HIGH POWER DEVICES AND THREE PHASE CONVERTERS (09)

High power devices for power system controllers – Characteristics - Converters configurations for large power control. Properties of three phase converters - Current and voltage harmonics - Effects of source and load impedance - choice of best circuit of power system.

CONVERTER CONTROL (09)

Gate control - Basic means of control - Control characteristics – stability of control- Reactive power control.

HVDC SYSTEMS (08)

Application of converters in HVDC system - Static VAR control - Sources of reactive power -Harmonics and filters.

WIND ENERGY AND PV ENERGY CONVERSION SYSTEM (10)

Basic components - Generator control – Harmonics - Power factor improvement. Different schemes for PV energy conversion - DC and AC power conditioners - Synchronized operation with grid supply - Harmonic problems.

POWER FLOW ANALYSIS (09)

Component models - Converter model - Analysis of converter - Transient and Dynamic stability analysis - Protection.

Total : 45 Hrs

Reference Books

1. *Padiyar.K.R.,"**HVDC Power Transmission System**", Wiley Eastern Limited, New Delhi, 2011.*
2. *Rai.G.D., "**Solar Energy Utilization**", Khanna Publishers, New Delhi, 2005.*
3. *Daniel, Haunt.V, "**Wind Power-A Handbook of WECS**",Van Nostrand Co.,New York, 1981.*
4. *Rakesh Das Bagamudre, "**Extra High Voltage AC Transmission Engineering**", New Age International Ltd., Third Edition, 2006.*
5. *R.Sastry Vedam, S.Sarma, " **Power Quality VAR compensation in Power systems**", CRC Press,2009.*

12PE29 FLEXIBLE AC TRANSMISSION SYSTEMS

(Common to PSE and PED)

L	T	P	C
3	0	0	3

INTRODUCTION (09)

FACTS-a toolkit, Basic concepts of static VAR compensator,Resonance damper, Thyristor controlled series capacitor,Static condenser, Phase angle regulator, and other controllers.

SERIES COMPENSATION SCHEMES (09)

Sub-Synchronous resonance,Torsional interaction,torsional torque,Compensation of conventional, ASC,NGH damping schemes,Modelling and control of thyristor controlled series compensators.

UNIFIED POWER FLOW CONTROL (09)

Introduction, Implementation of power flow control using conventional thyristor.Unified power flow concept, implementation of unified power flow controller.

DESIGN OF FACTS CONTROLLERS (09)

Approximate multi model decomposition,Variable structure FACTS controllers for Power system transient Stability, Non linear variable -structure control, variable structure series capacitor control and Variable structure series resistor control, Modeling and methods of analysis of FACTS controllers.

STATIC VAR COMPENSATION (09)

Basic concepts, Thysistor controlled reactor (TCR), Thyristor switched reactor (TSR), Thyristor Switched capacitor (TSC), Saturated reactor (SR), Fixed Capacitor (FC).

Total : 45 Hrs

Reference Books

1. *Hingorani Narin G., Gyugyi Laszlo, "**Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems**", Wiley-IEEE Press, 2000.*
2. *Narin G.Hingorani, "**Flexible AC Transmission**", IEE Spectrum,April1993, pp 40-45.*
3. *Narin G.Hingorani,"**High Power Electronics and Flexible AC Transmission Systems",** IEEE High Power Engineering Review,1998.*
4. *Narin G.Hingorani,"**Power Electronics in Electric Utilities:Role of Power Eletronics in future power systems**",proc.of IEEE,Vol.76.no.4, April 1988.*
5. *Einar V.Larsen, Juan J.Sanchez-gasca and Joe H.chow"**Concepts for design of FACTS controller to damp power swings**", IEEE Trans on Power System vol 10, no2, May 1995.*

12PE30 ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY IN SYSTEM DESIGN

L	T	P	C
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EMI ENVIRONMENT (09)

EMI/EMC concepts and definitions, Sources of EMI, conducted and radiated EMI, Transient EMI, Time domain Vs Frequency domain EMI, Units of measurement parameters, Emission and immunity concepts, ESD.

EMI COUPLING PRINCIPLES (09)

Conducted, Radiated and Transient Coupling, Common Impedance Ground Coupling, Radiated Common Mode and Ground Loop Coupling, Radiated Differential Mode Coupling, Near Field Cable to Cable Coupling, Power Mains and Power Supply coupling.

EMI/EMC STANDARDS AND MEASUREMENTS (09)

Civilian standards - FCC, CISPR, IEC, EN, Military standards - MIL STD 461D/462, EMI Test Instruments / Systems, EMI Shielded Chamber, Open Area Test Site, TEM Cell, Sensors / Injectors/ Couplers, Test beds for ESD and EFT, Military Test Method and Procedures.

EMI CONTROL TECHNIQUES (09)

Shielding, Filtering, Grounding, Bonding, Isolation Transformer, Transient Suppressors, Cable Routing, Signal Control, Component Selection and Mounting.

EMC DESIGN OF PCBs (09)

PCB Traces Cross Talk, Impedance Control, Power Distribution Decoupling, Zoning, Motherboard Designs and Propagation Delay Performance Models.

Total: 45 Hrs

Reference Books

1 *Henry W.Ott, "**Noise Reduction Techniques in Electronic Systems**", John Wiley and Sons, NewYork, Second Edition, 1988.*

2 *Paul C.R., "**Introduction to Electromagnetic Compatibility**" , John Wiley and Sons Inc., Second Edition, 2006.*

3 *Kodali V.P., **"Engineering EMC Principles, Measurements and Technologies"**, IEEE Press, 1996.*

4. *Bernhard Keiser, "**Principles of Electromagnetic Compatibility**", Artech house, Third Edition, 1987.*

12PE31 POWER ELECTRONICS IN WIND AND SOLAR POWER CONVERSION

L	T	P	C
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ENERGY SOURCES AND UTILITIES (08)

Trends in energy consumption - World energy scenario – Energy sources and their availability - Conventional and renewable sources - Need to develop new energy technologies and Hybrid Systems - Stand alone inverters - Charge controllers - Water pumping, Audio visual equipments, Street lighting.

PHOTOVOLTAIC ENERGY CONVERSION (08)

Solar radiation and measurement - Solar cells and their characteristics - Influence of insulation and temperature - PV arrays - Electrical storage with batteries - Solar availability in India - Switching devices for solar energy conversion - Maximum power point tracking - Analysis of Photo Voltaic Systems.

POWER CONDITIONING SCHEMES (10)

DC Power conditioning Converters - Maximum Power point tracking algorithms - AC Power conditioners - Line commutated inverters - Synchronized operation with grid supply - Harmonic problem - Grid connectors concepts - Wind farm and its accessories - Grid related problems - Generator control - Performance improvements - Different schemes - AC voltage controllers - Harmonics and PF improvement.

STAND ALONE SYSTEMS (10)

Self Excited Induction Generator (SEIG) for isolated Power Generators - Theory of self excitation - Capacitance requirements - Power conditioning schemes - Controllable DC Power from SEIGs - System performance - Wind / Solar PV integrated systems - Selection of power conversion ratio - Optimization of system components - Storage - Reliability evolution.

WIND ENERGY SYSTEMS (09)

Basic Principle of wind Energy conversion - Nature of Wind - Wind survey in India - Power in the wind - Components of Wind Energy Conversion System (WECS)- Performance of Induction Generators(SCIG and DFIG) and PMSGs for WECS - Classification of WECS .

Total : 45 Hrs

Reference Books

1. *Mukund R Patel, "**Wind and Solar power systems: design, analysis and operation**", Second Edition, Taylor & Francis, 2006.*
2. *Rai, G.D., "**Non-conventional Energy Sources**", Khanna Publications, New Delhi, IV Edition, 2009.*
3. *Daniel, Hunt, V.,"**Wind Power-AHandbook of WECS**",Van Nostrand Co., New York, 1998.*
4. *Thomas Markvart and Luis Castaser, "**Practical handbook of Photovoltaics**", Elsevier Publications, UK, 2003.*
5. *Gary L.Johnson,"**Wind Energy Systems**",Prentice Hall Inc,2001.*

12PE32 PULSE WIDTH MODULATION FOR POWER CONVERTERS

L	T	P	C
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MODULATION OF ONE INVERTER PHASE LEG (09)

Fundamental Concept of PWM-Evaluation of PWM Schemes-Double Fourier Integral Analysis of a Two-Level PWM waveform-Naturally Sampled PWM-PWM Analysis by Duty Cycle Variation-Regular Sampled PWM.

MODULATION OF SINGLE-PHASE VOLTAGE SOURCE INVERTERS (09)

Topology of a Single Phase Inverter-Three level Modulation of a Single Phase Inverter-Analytic Calculation of Harmonic Losses-Sideband Modulation-Switched Pulse Position-Switched Pulse Sequence.

MODULATION OF THREE-PHASE VOLTAGE SOURCE INVERTERS (09)

Topology of a Three Phase VSI-Three Phase Modulation with Sinusoidal Reference Books-Third Harmonic Reference Injection-Analytic Calculation of Harmonic Losses-Discontinuous Modulation Strategies-Triplen Carrier Ratios and Sub harmonics.

ZERO SPACE VECTOR PLACEMENT MODULATION STRATEGIES (09)

Space Vector Modulation-Phase Leg Reference Books for SVM-Naturally Sampled SVM-Analytical Solution for SVM-Harmonic Losses for SVM-Placement of the Zero Space Vector-Discontinuous Modulation.

PROGRAMMED MODULATION STRATEGIES (09)

Optimized Space Vector Modulation-Harmonic Elimination PWM-Performance Index for Optimality-Optimum PWM-Minimum Loss PWM.

Total: 45 Hrs.

Reference Books

1. *D.Grahame Holmes, Thomas A. Lipo, "**Pulse Width Modulation For Power Converters; Principles and Practice**," John Wiley & Sons, Inc., Publications, 2003*
2. *Dorin O. Neacsu," **Power Switching Converters**", CRC Press,"Taylor & Francis, 2006.*

12PE33 MODERN DIGITAL SIGNAL PROCESSING

L	T	P	C
3	0	0	3

DISCRETE RANDOM SIGNAL PROCESSING (09)

Discrete random process – stationary process, ensemble averages, auto correlation, auto covariance matrices, mean ergodic process and correlation – ergodic process. Parseval's theorem – Wiener Khintchine relation – power density spectrum – low pass and high pass filters.

SPECTRUM ESTIMATION AND ANALYSIS (09)

Principles – Traditional methods, pitfalls, windowing, periodogram, modified periodogram, Blackman–Turkey method, fast correlation method. AR model – Yule-Walker method, Burg method – MA model – ARMA model.

LINEAR PREDICTION (09)

Forward and backward predictions, Solution of the normal equations – Levinson-Durbin algorithms. Least mean squared error criterion – FIR Wiener filter and Wiener IIR filters – Wiener filter for filtering and prediction.

ADAPTIVE FILTER (09)

Concepts of adaptive filter – FIR adaptive filters – LMS adaptive algorithm – Adaptive recursive filers – design by time domain and frequency domain equivalence criterion – Adaptive noise and echo cancellation – AR lattice and ARMA lattice – ladder filters.

MULTIRATE DIGITAL SIGNAL PROCESSING (09)

Mathematical description of sampling rate – Interpolation and Decimation by integer factor – Sampling rate conversion by rational factor- Filter design for sampling rate conversion; direct form FIR structures, Polyphase structures, time-variant structures. Multistage implementation of multirate system. Applications – High quality analog to digital conversion for digital audio, efficient implementation of narrowband digital filters.

Total : 45 Hrs.

Reference Books

1. *Monson H.Hayes, "**Statistical Digital Signal processing and Modeling**", John Wiley and Sons Inc., New York, 2009.*
2. *John G. Proakis, Dimitris G.Manolakis, "**Digital Signal Processing: Principles, Algorithms and Applications**" PHI, Fourth Edition, Fourth edition, 2007.*
3. *Emmanuel C. Ifeachor, Barrie W. Jervis, "**Digital Signal Processing – A Practical Approach**", Addison–Wesley publishing company, Second Edition, 2009.*
4. *Sanjit K.Mitra."**Digital Signal Processing.**" Tata McGraw Hill, April, 2011.*

12PE34 WAVELETS AND APPLICATIONS

L	T	P	C
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INTRODUCTION (09)

Vector spaces-properties-dot product-basis-dimension, orthogonality and orthonormality-relationship between vectors and signals-signal spaces-concept of convergence-Hilbert spaces for energy signals-Generalized Fourier expansion.

FOURIER ANALYSIS (09)

Fourier Transform-drawbacks of Fourier analysis-Short-time Fourier Transform (STFT) analysis-spectrogram plot-phase-space plot in time-frequency plane-Time and frequency limitations-uncertainty principle-Tilling of the time-frequency plane for STFT

CONTINUOUS WAVELET TRANSFORM (09)

Wavelet transform-properties-concept of scale and its relation with frequency-Continuous Wavelet Transform (CWT)-scaling function and wavelet functions: Daubechies, Haar, Coiflet, Mexican hat, Sine, Gaussian, Bi-orthogonal-Tilling of time scale plane for CWT.

DISCRETE WAVELET TRANSFORM (09)

Discrete Wavelet Transform (DWT)-Filter bank and sub-band coding principles-Multi-resolution analysis-Time scale difference equations for wavelets and scaling functions-Wavelet filters-scale variation in discrete domain-Mallet's algorithm for DWT-Inverse DWT computation by filter banks-multi-band wavelet transform.

CASE STUDIES (09)

Sub-band coding of images-Image compression-Image de-noising-Detection of sag, tilt, swells and surge in power signal-Fractal signal analysis.

Total : 45 Hrs.

Reference Books

1. *Strang G Nguyen T., "**Wavelets and Filter Banks**", Wellesley Cambridge Press, 1996.*
2. *Vetterli M, Kovacevic J., "**Wavelets and Sub-band Coding**", Prentice Hall, 1995.*
3. *Mallat S., "**A Tour on Wavelet Signal Processing**", Elsevier, New Delhi, December 2005.*
4. *Rao .R.M and Bopardikar.A.S, "**Wavelet Transforms**", Addison Wesley, 1999.*
5. *K.P.Soman and K.I.Ramachandran "**Insight into Wavelets-From Theory to Practice**", Prentice Hall of India, 2005.*
6. *Meyer Y et.al., "**Wavelet Toolbox Manual**", Mathworks Inc., 1995.*

12PE35 RESEARCH METHODOLOGY

L	T	P	C
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INTRODUCTION TO RESEARCH METHODOLOGY (09)

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

SCALES – MEASUREMENT AND SAMPLING METHODS (09)

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

HYPOTHESES TESTS (09)

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

NONPARAMETRIC TESTS (09)

Nonparametric tests- One sample tests – one sample sign test, Kolmogorov-Smirnov test, run test for randomness, Two sample tests – Two sample sign test, Mann-Whitney U test, K-sample test - Kruskal Wallis test (H-Test).

RESEARCH ANALYSIS AND REPORT WRITING (09)

Introduction to Disciminant analysis, Factor analysis, cluster analysis, multidimensional scaling, conjoint analysis.Report writing- Types of report, guidelines to review report, typing instructions, oral presentation.

Total : 45 Hrs.

Reference Books

1. *Kothari, C.R.,* ***"Research Methodology –Methods and techniques"****, New Age Publications, New Delhi, Second Edition, 2009.*
2. *Panneerselvam, R.,* ***"Research Methodology"****, Prentice-Hall of India, New Delhi, 2004.*

12PE36 COMPUTER NETWORK ENGINEERING

L	T	P	C
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PROTOCOLS OF ARCHTECTURE (09)

Data communication-Protocols and standards-Basic concepts-Line configuration-Topology-Transmission modes-Categories of Networks-Internetworks-OSI Model-Functions of the layers

COMMUNICATION MEDIA AND DATA LINK PROTOCOLS (09)

Dail up MODEMS, Digital Subscriber Line (DSL)-Internetworking Devices or Connecting devices- Repeater, Bridge, Routers and Gateways. Flow control and error control, stop and wait, Sliding windows, Automatic Repeat (ARQ),

LOCAL AREA NETWORKS AND WIDE AREA NETWORKS (09)

Wired LAN:IEEE 802 standards, LLC, MAC layer protocols – CSMA/CD Ethernet, Token Bus, Token Ring,FDDI-Wireless LAN:Bluetooth-Architecture-Layers-L2CAP WAN: Circuit Switch packet Switch, Message Switching, X .25 Protocols- Architecture and Layers of Protocol, Frame Delay, ISDN and ATM Protocol

TRANSPORT PROTOCOLS AND ROUTING TECHNIQUES (09)

Duties of transport layer-Connection-The OSI transport protocol-UDP-SCTP-Overview of Routing Techniques

UPPER OSI LAYERS (09)

Session layer protocols, Presentation layer – Data Security, Encryption/Decryption, Authentication,Data Composition, Application layer protocols – MHS - File transfer, Virtual terminal, CMIP.

Total : 45 Hrs.

Reference Books

1. *Behrouz A Forouzan , "**Data Communication and Networking**", Second Edition, Tata McGraw- Hill, 2002.*
2. *William Stallings, "**Data and Computer Communication**", 9th Edition, Prentice Hall of India, 2010.*
3. *Andrew S.Tanenbaum, "**Computer networks**", Fourth Edition, Prentice Hall of India, 2003.*
4. *Brijendra Singh, "**Data Communication and Computer Networks**", Second Edition, Prentice Hall of India, 2006.*

12PE37 MODEL PREDICTIVE CONTROL

(Common to PSE and PED)

L	T	P	C
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BASICS (09)

Model predictive control-introduction model predictive control strategy- Model predictive control elements –predictive model process model-objective function-control law –state space formulation.

LINEAR CONTROL (09)

Model predictive control Schemes –Dynamic matrix control- Model algorithmic control-predictive functional control-Formulation of generalized Model predictive control-closed loop relationships.

NON-LINEAR CONTROL (09)

Non-linear Model predictive control- Non-linear Model predictive control vs linear Model predictive control-Non-linear models-solution of non-linear model predictive control-technique for Non-linear Model predictive control-stability of Non-linear Model predictive control.

IMPLEMENTATION (09)

Methods of implementing Model predictive control-Model predictive control and multi parametric programming-implementation of model predictive control for uncertain systems-closed loop min-max model predictive control implementation of model predictive control and dead time consideration.

APPLICATIONS (09)

Case study model predictive control on a chip-FPGA implementation of MPC –FPGA implementation of MPC for petrochemical process.

Total : 45 Hrs.

Reference Books

1 *E.F.Camacho and C.Bordons,* ***"Model Predictive Control",*** *Springer, 2nd Edition,2004.*

2. *Keck Voontuing, jan Maciefouski, Being Fan Wu,* ***"Multiplexed Model Predictive Control",*** *Department of Engg, Univ, 2006.*

3. *Carlos E.Garcia et.al.,* ***"Model predictive control: Theory and Practice"*** *–A survey Springer, 2004.*

12PE38 VIRTUAL INSTRUMENTATION

(Common to PSE and PED)

L	T	P	C
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REVIEW OF VIRTUAL INSTRUMENTATION (09)

Historical Perspective - Advantages etc - Block diagram and architecture of a virtual instrument.

DATA FLOW TECHNIQUES (09)

Graphical programming in data flow - comparison with conventional programming.

VI PROGRAMMING TECHNIQUE (09)

VIS and Sub-VIS - Loops and charts- Arrays - Clusters - Graphs - Case and sequence structures - Formula nodes - Local and global variables - String and file I/O

DATA ACQUISITION AND INSTRUMENT INTERFACE (09)

ADC - DAC - DIO - Counters and timers - PC hard ware structure - Timing - interrupts - DMA - Software and hardware installation - Current loop - RS –232 C / RS – 485- GPIB- USB and PCMCIA.

ANALYSIS TOOLS AND APPLICATIONS (09)

Some tools from the advanced analysis tools relevant to the discipline may be included Eg. Fourier transform - Power spectrum - Correlation methods - Windowing and filtering. VI application in various fields – VISA and IVI – Image acquisition and processing.

Total : 45 Hrs.

Reference Books

1. *Jovitha Jerome, " **Virtual Instrumentation using labview**", Prentice Hall, India, 2010.*
2. *Sanjav Gupta and Joseph John, "**Virtual Instrumentation using Labview**", Tata McGraw Hill, May 2010.*
3 *Cory L.Clark, "**LabVIEW Digital Signal Processing and Digital Communications**", Tata McGraw Hill, 2005.*
4. *Gray Johnson,'**Lab VIEW Graphical Programming'** 4th Edition., McGraw Hill, August-2006.*
5. *Jeffrey Travis, '**LabVIEW for Everyone**', 3rd Edition, Prentice Hall, 2006.*

12PE39 DATA ACQUISITION SYSTEMS

L	T	P	C
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SENSORS AND DATA ACQUISITION (09)

Transducer - Characteristics - Classification - Transducers for displacement , temperature, pressure, liquid level - Intelligent sensors – Biosensors.

DATA TRANSMISSION (09)

Analog and digital transmission - Wire and radio transmission - Fibre optic transmission - RS 232 and IEEE488 standards - Local area networks.

BUILDING BLOCKS OF AUTOMATED SYSTEMS (09)

Processing system - Multi-microprocessor systems - Local area networks - Analog and digital I/O modules - Supervisory control and data acquisition system - Remote terminal unit.

PROGRAMMABLE CONTROLLERS (09)

Principles of operation - Architecture - Programming - Applications.

PERSONAL COMPUTER IN REAL TIME ENVIRONMENT (09)

PC Bus and signals - Interrupts - Interfacing - PC in real time environment - Applications - Overview of LABVIEW software.

Total : 45 Hrs.

Reference Books

1. *Krishna Kant, "**Computer Based Industrial Control**", 2nd Edition, Prentice Hall of India, May 2009.*
2. *Chesmond, Wilson and Lepla , "**Advanced Control System Technology**", Viva low priced Edition,1998.*
3. *Gary Johnson, Richard Jennings, "**LabVIEW Graphical Programming**", 4th Edition, , McGraw Hill, August 2006.*
4. *Sokoloff, "**Basic Concepts of LabVIEW 4**", Prentice Hall, 1998.*

12PE40 INDUSTRIAL ROBOTICS AND AUTOMATION

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FUNDAMENTAL CONCEPTS OF ROBOTICS (08)

History, Present status and future trends in Robotics and automation - Laws of Robotics - Robot definitions - Robotics systems –Types- robot anatomy - Specification of Robots - resolution, repeatability and accuracy of a manipulator - Robotics applications.

ROBOT DRIVES AND POWER TRANSMISSION SYSTEMS (09)

Robot drive mechanisms, hydraulic – electric – servomotor- stepper motor - pneumatic drives, Mechanical transmission method - Gear transmission, Belt drives, cables, Roller chains, Link-Rod systems - Rotary-to-Rotary motion conversion, Rotary-to-Linear motion conversion, Rack and Pinion drives, Lead screws, Ball Bearing screws, End effectors -Types.

SENSORS (09)

Sensor characteristics, Position sensors – Potentiometers – Encoders – Resolvers – LVDT, Velocity sensors – Tachogenerators - Encoders - Proximity sensors, Limit switches – Tactile sensors - Touch sensors - Force and torque sensors.

VISION SYSTEMS FOR ROBOTICS (09)

Robot vision systems, Image capture- cameras – vidicon and solid state Image representation - Gray scale and colour images, image sampling and quantization - Image processing and analysis - Image data reduction - Segmentation - Feature extraction - Object Recognition- Image capturing and communication - JPEG, MPEGs and H.26x standards, packet video, error concealment.- Image texture analysis - Motion generation - Manipulator dynamics - Jacobian in terms of D-H matrices - Controller architecture.

PLC AND AUTOMATION (10)

Building blocks of automation, Controllers – PLC- Role of PLC in FA - Architecture of PLC - Advantages - Types of PLC - Types of Programming - Simple process control programs using Relay Ladder Logic and Boolean logic methods - PLC arithmetic functions - Flexible Manufacturing Systems concept - Automatic feeding lines, AS/RS, transfer lines, automatic inspection - Computer Integrated Manufacture - CNC, intelligent automation - Industrial networking, bus standards, HMI Systems, DCS and SCADA, Wireless controls.

Total : 45 Hrs.

Reference Books

1. *Richard D Klafter, Thomas A Chmielewski, Michael Negin, "**Robotics Engineering – An Integrated Approach**", Eastern Economy Edition, Prentice Hall of India Pvt. Ltd., 1989.*
2. *Fu K.S., Gomalez. R.C. and Lee C.S.G., "**Robotics : Control, Sensing, Vision and Intelligence**", McGraw Hill Book Company, 1987.*
3. *Mikell P Groover et. al., "**Industrial Robots - Technology, Programming and Applications**", McGraw Hill, New York, 1986.*

4. *Saeed B Niku, "**Introduction to Robotics Analysis,Systems,Applications**", PHI Pvt. Ltd. New Delhi, 2003.*

5. *Deb S R., "**Robotics Technology and Flexible Automation**", Tata McGraw Hill Publishing, Company Ltd., 2009.*

6. *Saha S.K., **" Introduction to robotics**," Tata MaGraw Hill Publishing company Ltd, 2008.*

7. *Peter Conke, **" Robotics-Vision and Control: Fundamental algorithm in MATLAB**," Springer, Ist Edition, Sep 2011.*

8. ***MATLAB for Engineers-Applications in control**, Electrical Engineering, IT and Robotics. InT. Ch. Pulishers, Ist Edition, 2011.*

12PE41 VLSI CIRCUITS AND SYSTEMS

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MOS TECHNOLOGY AND ELECTRICAL PROPERTIES (09)

Basic MOS transistors – Enhance mode – Depletion mode – nMOS fabrication – CMOS fabrication – Darin current – Threshold voltage – Transconductance and output conductance – Figure of merit – nMOS inverter – Pullup to pulldown ratio – CMOS inverter – Circuit model – Latch up in CMOS.

MOS CIRCUIT DESIGN PROCESS, CONCEPTS AND SCALING (09)

Stick Diagrams – Design rules and layouts – Sheet resistance – Sheet resistance concept applied to MOS transistors and inverters – Area Capacitance of layers – Standard unit of area capacitance – Area capacitance calculations – Delay unit – Inverter delays – Driving large capacitive loads – Propagation delays – Wiring capacitance – Choice of layers – Scaling factors for device parameters – Limitations of scaling – Limitations on logic levels and supply voltage – Limitations due to current density.

SUBSYSTEM DESIGN AND LAYOUT (09)

Architectural issues – Switch logic – Gate logic – Examples of structured design for parity generator, bus-arbitration logic, multiplexers, general logic function and PLA– Clocked sequential circuits of two-phase clocking, charge storage, dynamic register element and dynamic shift register – System considerations.

SUBSYSTEM DESIGN PROCESS (09)

General considerations – General arrangement of a 4-bit arithmetic processor – Design of a 4-bitshifter – Design of a 4-bit adder – Manchester carry chain – Adder enhancement techniques – Serial-parallel multiplier – Braun array – Twos compliment multiplication – pipelined multiplier – Modified Booth's algorithm – Wallace multiplier – Recursive decomposition of multiplication.

MEMORY AND CASE STUDIES (09)

System timing considerations – Dynamic shift register – Three transistor DRAM – One transistor DRAM – Dynamic and static memory cells – JK and D flipflops – Formation of arrays – Design case studies of incremenenter/decrementer, shift register and n-bit comparator.

Total : 45 Hrs.

Reference Books

1. *Kamran Eshraghian, Douglas A.Pucknell and Sholeh Eshraghian, "**Essentials of VLSI Circuits and Systems**", Prentice Hall of India Pvt. Ltd., New Delhi, 2005.*
2. *Neil H.E. Weste, David Harris and Ayan Banerjee, "**CMOS VLSI Design, A Circuits and Systems Perspective**", Third Edn., Pearson, 2006.*
3. *Wolf W., "**Modern VLSI Design**", Pearson Education, Fourth Edition, 2009.*
4. *Sze S.M., "**VLSI Technology**", Second Edn., McGraw Hill, 12th reprint, 2008.*