M.TECH IN ELECTRICAL AND ELECTRONICS ENGINEERING
(ELECTRICAL DRIVES AND CONTROL)

CURRICULUM AND SYLLABUS

(Effect from the Academic Year 2011 – 12)

Offered by

Electrical and Electronics Engineering Department
PONDICHERRY ENGINEERING COLLEGE

Affiliated to

Pondicherry University
PUDUCHERRY – 605014.

SEMESTER – I

Code	Subject	Periods			Credits	Marks		
		L	**T**	**P**		**IE**	**UE**	**TM**
EE 900	Modern Control Theory	3	1	0	4	40	60	100
EE 901	Power Electronic Circuits and Systems	3	1	0	4	40	60	100
EE 902	Solid State Controlled Electrical Drives	3	1	0	4	40	60	100
	Elective – I	3	0	0	3	40	60	100
	Elective – II	3	0	0	3	40	60	100
EE 907	Solid State Systems Laboratory	1	0	3	2	50	50	100
	Total	16	03	03	20	250	350	600

SEMESTER – II

Code	Subject	Periods			Credits	Marks		
		L	**T**	**P**		**IE**	**UE**	**TM**
EE 903	Digital Control and Controller Design	3	1	0	4	40	60	100
EE 904	Mathematics	3	1	0	4	40	60	100
EE 905	Vector Controlled AC Drives	3	1	0	4	40	60	100
	Elective – III	3	0	0	3	40	60	100
	Elective – IV	3	0	0	3	40	60	100
EE 908	Controlled Electrical Drives Laboratory	1	0	3	2	50	50	100
EE 906	Seminar	0	0	3	2	100	-	100
	Total	16	03	06	22	350	350	700

SEMESTER – III

Code	Subject	Periods			Credits	Marks		
		L	**T**	**P**		**IE**	**UE**	**TM**
	Elective – V	3	0	0	3	40	60	100
	Elective – VI	3	0	0	3	40	60	100
EE 960	Directed Study	0	0	3	2	100	-	100
EE 909	Dissertation Project (Phase I)	0	0	18	9	150	150	300
	Total	06	00	21	17	330	270	600

SEMESTER – IV

Code	Subject	Periods			Credits	Marks		
		L	**T**	**P**		**IE**	**UE**	**TM**
EE 910	Dissertation Project (Phase II)	0	0	36	14	200	200	400
	Total	00	00	36	14	200	200	400

EE-Electrical Electronics; L-Lecture, T-Tutorials; P-Practical;

LIST OF ELECTIVES

Sl.No.	Code	Subject
1.	EE 911	Adaptive Control Theory
2.	EE 912	Advanced Digital Signal Processing
3.	EE 913	Diagnosis and Protection for Solid State Systems
4.	EE 914	Embedded Systems
5.	EE 915	FPGA based System Design
6.	EE 916	Fuzzy Control
7.	EE 917	Modern Power Electronic Converters
8.	EE 918	Neural Networks
9.	EE 919	Nonlinear Control Systems
10.	EE 920	Optimal Control Theory
11.	EE 921	Power Electronics in Power System
12.	EE 922	Power Quality
13.	EE 923	Renewable Energy Electrical Systems
14.	EE 924	Special Electrical Machines

EE 900 MODERN CONTROL THEORY

UNIT-I: INTRODUCTION TO STATE SPACE APPROACH

Modeling of physical systems using state space approach – advantages of state space approach over transfer function model.

State diagram, state space and state trajectory – state space realization – controllable, observable, diagonal and Jordan canonical forms - Similarity transformation – Transformation into various canonical realizations.

Solution of Linear Time Invariant (LTI) state equation – state transition matrix and its properties – computational techniques.

UNIT-II: STATE SPACE ANALYSIS

Eigen values and Eigen vectors – Cayley Hamilton theorem – minimal polynomial concept – Controllability and Observability – Tests – Kalman decomposition technique.

UNIT-III: STATE FEEDBACK CONTROLLER DESIGN

Controller design by state feedback –Necessary and Sufficient condition for arbitrary pole placement- state regulator problem.
tracking (Servo) problem – State feedback with integral control. Eigen structure assignment.

Observer Design – Full order/reduced order observer design – observer based state feedback control – separation principle.

UNIT-IV: STABILITY ANALYSIS

Stability concepts – BIBO Asymptotic stability - stability definitions in state space domain – stability theorems on local and global stability – Lyapunov stability analysis - Krasovskii Method.

UNIT-V: OPTIMAL CONTROL

Linear quadratic optimal regulator (LQR) problem formulation – optimal regulator design by parameter adjustment (Lyapunov method) – optimal regulator design by Continuous - time Algebraic Riccatti Equation (CARE) - Introduction to Kalman filter – optimal controller design using LQG framework.

TEXT BOOKS

1. Katsuhiko Ogata, “Modern Control Engineering”, Prentice hall of India pvt. Ltd., New Delhi -110001, 1989.
2. Katsuhiko Ogata, “State Space Analysis of Control Systems”, Prentice hall Inc., New Jersey, 1967.

REFERENCE BOOKS

1. Biswa Nath Datta, “Numerical Methods for Linear Control Systems”, Elsevier, 2005.
2. Gene.F.Franklin, J.David Powell and Abbas Emami-Naeini, “Feedback Control of Dynamic Systems”, Pearson Edu. Asia, 2002.
3. Chi-Tsong chen, “Linear System Theory and Design”, 3rd edition, oxford press, 1999.

EE 901 POWER ELECTRONIC CIRCUITS AND SYSTEMS

UNIT-I: NATURAL COMMUTATED CONVERTERS

Single phase and three phase controlled rectifier – operation and performance analysis of half and fully controlled converter with RL, RLE loads with and without freewheeling diodes - converter - inverter operation - effect of source impedance - inverter limit - performance at input and output – harmonics - ripple.

Load commutated and forced commutated operations – various modes, Dual converters, higher pulse converters.

UNIT-II: CYCLO-CONVERTER AND VOLTAGE CONTROLLER

Principle of operation of cycloconverters - three phase to single phase - three phase to three phase - input and output performances - output voltage and frequency ranges - harmonics - pulse generation and controls for cycloconverter.

Introduction to bi-directional switches - Single phase and three phase ac voltage controller - output voltage control – phase angle range – per unit plot for various loads - input and output performance –gating requirements – harmonics.

UNIT-III: FORCED COMMUTATED CONVERTERS

DC choppers - operation of choppers - forced commutated principle - voltage and current commutated choppers - choice of commutation circuit element – class A,B,C,D and E choppers – chopper design – applications – design principles.

Inverters - Single phase forced commutated inverter – voltage source – current source - analysis with R and RL loads – applications - design principles.

UNIT-IV: MODULATION TECHNIQUES

Single-phase inverters: Principle of operation of half and full bridge inverters – Performance parameters – Voltage control - various PWM techniques – square wave – SPMW – unipolar – bipolar operation - Discontinuous PWM - low and high frequency switching operation – performance comparison.

Three-phase inverters: Principle of operation of 180 degree and 120 degree conduction mode inverters with star and delta connected loads – voltage control of three phase inverters - Voltage control techniques – SVPWM – Multiphase inverter operation for high power.

UNIT-V: HIGH POWER APPLICATIONS

High power converters - higher pulse operation - series connected - parallel connected converters - high power inverters - phase shifted operation – parallel connected – cascaded connected inverters – inverters with/without transformer – design of high power converters and inverters.

Introduction to multilevel inverters - diode clamped, flying capacitor, cascade type multilevel inverters -comparison of multilevel inverters - applications.

TEXT BOOKS

1. Power Electronics, M.D.Singh, and K.B.Khanchandani, Tata McGraw-Hill Publishing Company Limited, New Delhi 2003.
2. Power Electronics Circuits, Devices and Applications, Rashid M.H, Prentice Hall India, Third Edition, New Delhi, 2004.
3. Power Electronics, Mohan, Underland and Robbins, John Wiley &Sons, 1995.

REFERENCE BOOKS

1. Power Electronics, Cyril Lander, McGraw Hill, Int.Edit, 1993.
2. Power Electronics Systems, Jai P.Agrawal, Pearson Education, Second Edition, 2002.

3. Power Electronics Converter Harmonics: Multipulse Methods for Clean Power, Derek A. Paice, Wiley-IEEE Press, 1999.
4. Pulse Width Modulation for Power Converters: Principles and Practice, D. Grahame Holmes, Thomas A. Lipo, Wiley-IEEE Press, Year.
5. Introduction to Modern Power Electronics, Andrzej M. Trzynadlowski, John Wiley & Sons, 2010.
6. Self-Commutating Converters for High Power Applications, Jos Arrillaga, Yonghe H. Liu, Neville R. Watson, Nicholas J. Murray, "", John Wiley & Sons, 2009.

EE 902 SOLID STATE CONTROLLED ELECTRICAL DRIVES

UNIT-I: SPEED CONTROL OF DC MOTORS

Industrial motor drive requirements - typical load torque speed curves - energy savings - variable speed drives - load dynamics and modeling - load type and duty ratio - motor choice - speed control principles - constant torque - constant power – multi quadrant operations.

Solid state controlled DC motor - converter fed - chopper fed – operating modes – configurations - speed control – torque control – speed reversal - braking - regeneration - closed loop regulation - Inching – jogging – effect of saturation.

UNIT-II: DESIGN OF CONTROLLER AND CONVERTER FOR DC DRIVES

Closed loop operation - speed regulation – speed loop - current loop – tracing of waveforms – speed reversal – torque reversal – with/ without braking and regeneration – design of converters and choppers - firing scheme - simulation.

Modeling of dc motors, converters, choppers - controller design, speed controller, current controller – performance analysis with and without current controller - simulation.

UNIT-III: SPEED CONTROL OF INDUCTION MOTOR – STATOR SIDE

Comparison of different ac power controllers – principles of speed control - variable voltage - variable frequency operation – constant flux operation - constant power operation – speed control of VSI and CSI fed drives - design examples.

Closed loop control schemes - dynamic and regenerative braking - speed reversal – tracing of critical waveforms - effect of non- sinusoidal supply.

UNIT-IV: SPEED CONTROL OF INDUCTION MOTOR – ROTOR SIDE

Torque slip characteristics – speed control through slip - rotor resistance control-chopper controlled resistance – equivalent resistance – TRC strategy – characteristic relation between slip and chopper duty ratio - combined stator voltage control and rotor resistance control – design solutions – closed loop control scheme.

Slip power recovery - torque slip characteristics - power factor considerations - sub and super synchronous operation - design solutions - closed loop control scheme.

UNIT-V: SPEED CONTROL OF SYNCHRONOUS MOTOR DRIVES

Need for leading PF operation - open loop VSI fed drive – group drive applications. Self control – margin angle control - torque angle control - power factor control - simple design examples

Closed loop speed control scheme with various power controllers - starting methods – brush less excitation systems.

TEXT BOOKS

1. Power semiconductor controlled devices, Dubey, G.K, Prentice Hall International Newjersey, 1989.
2. Electric Motor Drives – Modeling, Analysis and Control, R.Krishnan, Prentice-Hall of India Pvt. Ltd., New Delhi, 2003.
3. Thyristor control of AC motors, Murphy, J.M.D, Turnbull F.G., Pergamon press, Oxford, 1988.

REFERENCE BOOKS

1. High-Power Converters and AC Drives, Bin Wu, Wiley-IEEE Press.
2. A design of control systems for DC drives, Buxbaum, A.Schierau, and K.Staughen, Springer-Verlag, Berlin, 1990.

3. Modern Power Electronics and AC Drives, Bimal K.Bose, Pearson Education (Singapore) Pte. Ltd., New Delhi, 2003.
4. Variable Speed Electric Drives, Jean Bonal and Guy Seguier, Lavoisier c/o Springer verlag, May, 2000.
5. Control of Electrical Drives, Werner Leonhard, 3rd Edition, Springer, Sept., 2001.
6. Electric Motors and Drives: Fundamentals, Types and Applications, Austin Hughes, Newnes, Jan 2006.

EE 903 DIGITAL CONTROL AND CONTROLLER DESIGN

UNIT-I: INTRODUCTION

Introduction to discrete time control system - Sampling and holding - sample and hold device - D/A, A/D conversion – sampling theorem – data interpolation - Z transform –properties - inverse Z transform - Pulse transfer function

UNIT-II: STATE VARIABLE TECHNIQUE

State equations of discrete time systems – solution of state equation - state transition matrix, its properties – state space realization and state diagram – pulse transfer function from state equation - characteristic equation - Eigen values - Eigen vectors - Similarity transformation – transformation into various canonical forms.

UNIT-III: CONTROLLABILITY, OBSERVABILITY AND STABILITY

Controllability and observability of Llinear Time Invariant (LTI) discrete data systems – tests for controllability and observability - relationship between controllability, observability and pulse transfer functions.

Stability of LTI discrete time systems - Jury's stability tests - Bilinear transformation method - Lyapunov stability analysis.

UNIT-IV: CONTROLLER DESIGN – I

Correlation between root locations in Z-plane and time response - direct digital design in Z and W plane (under bilinear transform)

PID controllers – proportional, integral and derivative modes – discretization of continuous PID controller – conventional tuning procedures – Reaction curve method of Ziegler Nichols – stability method of Ziegler Nichols

UNIT-V: CONTROLLER DESIGN – II

State feedback - Design via pole placement – observer based state feedback - Introduction to digital redesign - optimal controllers – quadratic optimal control – steady state quadratic optimal control –optimal state estimation – Kalman filter - Extended Kalman filter.

TEXT BOOKS

1. K.Ogata, "Discrete time control systems", 2nd edition, Pearson Edu., 2003
2. Franklin, Powell, workman, "Digital control of Dynamic systems", 3rd edition, Pearson Edu., 2002.
3. Kannan M. Moudgalya, "Digital control", John Willy, 2008.

REFERENCE BOOKS

1. M.Gopal, "Digital Control and state variable methods", Tata McGraw hill, New Delhi, 2003.
2. Aashish Tiwari, "Modern control design with MATLAB and SIMULINK", John Wiley and sons Ltd., 2002
3. Benjin.Kuo, 'Digital Control systems', 2nd Edition, Oxford University, 1992.

EE 904 MATHEMATICS

UNIT-I: VECTOR SPACES

Vector spaces, subspaces, span of a set, linear independence and dependence, Dimension and Bases, inner product spaces - Gram-Schmidt orthogonalization.

UNIT-II: LINEAR TRANSFORMATIONS

Definition and examples, Range and Kernel of a linear map, rank and nullity, Inverse of a linear transformation, consequences of Rank-Nullity theorem, the space L (U, V), composition of linear maps, Matrix associated with a linear map and linear map associated with a matrix.

UNIT-III: LINEAR PROGRAMMING

Basic concepts – Graphical and Simplex methods - Big M-techniques – Two Phase methods.

UNIT-IV: DYNAMIC AND QUADRATIC PROGRAMMING

Dynamic Programming – Solutions of Problems using dynamic programming techniques – Definitions of convex programming - Kuhn Tucker conditions – Quadratic Programming – Wolf's Method.

UNIT-V: RANDOM PROCESS

Stochastic Process – Classification of Stochastic process - Poisson process - Gaussian process - Markov chains - Auto correlation - Cross correlation.

TEXT BOOKS

1. V. Krishnamurthy, V.P. Maiwa and J.L.Arora, An introduction to linear Algebra, Affiliated East West Press Pvt. Ltd., New Delhi-Madras.
2. Taha. H.A., operations research – An introduction, Mac Millian publishing Co., (1982).

REFERENCE BOOKS

1. Pant J.C. optimization and operations research, Jain Publishers, New Delhi.
2. Kishore S Trivedi, Probability and Statstics with Reliability, Queueing and Computer Science Applications, John Wiley & Sons (2002).

EE 905 VECTOR CONTROLLED AC DRIVES

UNIT-I: AC MOTOR MODELS

Vector control concept – d-q axes - linear transformations in machines - three phase to two phase – rotating axis to stationary axis - Park's Transformation for three phase induction motor (IM) – d-q axis equivalent circuit – effects of saturation – phase variable model of IM - scalar versus vector control.

UNIT-II: INDUCTION MOTOR VECTOR CONTROL FUNDAMENTALS

Vector control – general flux orientation – current decoupling – parameters detuning effects in rotor flux orientation current decoupling – direct versus indirect vector current decoupling – AC , DC current controllers – Voltage and current limitations - vector voltage control – constant air gap flux operation – constant rotor flux, stator flux operations – comparison.

UNIT-III: VECTOR CONTROL OF VSI AND CSI FED IM

Direct vector control – flux vector estimation – voltage, current models – indirect vector control – open loop flux control – synchronous current control – vector control of line side PWM rectifier – stator flux oriented control – Vector control of CSI fed drives – vector control of cycloconverter drive – modeling and simulation.

UNIT-IV: VECTOR CONTROL OF SYNCHRONOUS MOTOR DRIVES

D-q axis model of synchronous machines – variable γ^* control – constant γ^* control – vector current control – voltage control – torque vector control – steady state operation for given i_d - steady state operation for given stator flux - simulation.

UNIT-V: VECTOR CONTROL OF CYCLOCONVRTER FED SYNCHRONOUS MOTOR DRIVES

Stator flux orientation current control system – control equations - current controller – flux and current reference calculator - flux calculator – torque vector control – vector control of CSI fed drives – simulation.

TEXT BOOKS:

1. Modern Power Electronics and AC Drives, Bimal K.Bose, Pearson Education (Singapore) Ltd., New Delhi, 2003.
2. I Boldea and S.A.Nasar, Vector Control of AC Drives, CRC Press LLC, 1992

REFERENCE BOOKS

1. D.W. Novotny and T.A. Lipo, Vector control and dynamics of AC drives Oxford Science Publicatios, 1996.
2. Paul, C, Krause , Oleg Wasynczuk and Scott D. Subhoff, Analysis of Electric Machinery and Drive Systems, IEEE Press, Wiley Interscience, 2002.
3. Nguyen Phung Quang and Jorg-Andreas Dittrich, Vector Control of Three-phase AC Machines, Springer-Verlag Berlin and Heidelberg GmbH & Co. KG, 2008.
4. Vector Control of Three-Phase AC Machines: System Development in the Practice, Springer | 2008.
5. Ahmad, Mukhtar, High Performance AC Drives: Modelling Analysis and Control, Springer, 2010.

LIST OF ELECTIVES

Sl.No.	Code	Subject
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14.	EE 924	Special Electrical Machines

EE 911 ADAPTIVE CONTROL THEORY

UNIT-I: MODELING AND SIMULATION

Linear Feed back – Effect of process variations – Classifications of Adaptive control - Modeling – Frequency – Impulse – Step Response methods – Simulations of 1st and 2nd order systems.

UNIT-II: IDENTIFICATION TECHNIQUE

Off-line – on line methods – Least square – Recursive least square – fixed memory – maximum likelihood – Instrumental variable – stochastic approximate method.

UNIT-III: MRAS & STC

Introduction – the gradient approach – MIT rule Liapunov Functions – Control policies – Pole placement control – minimum variance control – Predictive control.

UNIT-IV: AUTO-TUNING AND GAIN SCHEDULING

PID control – auto tuning technique – Transient response methods – Methods based on relay feedback – Relay oscillations – Principle and design of gain scheduling controllers – Non linear transformations – Applications of gain scheduling.

UNIT-V: APPLICATIONS AND EXPERT CONTROL

Industrial adaptive controllers – Process control – ship steering – Adaptive signal processing – Extremum control – expert control system – Learning systems – Introduction to Neuro-Fuzzy controllers.

TEXT BOOKS

1. Adaptive Control, Karl.J.Astrom, Bjorn Witten mark, Pearson Education, pvt. Ltd 1995.
2. Goodwin G.C Sin KS New Jersey, “Adaptive Filtering, Prediction and control”, Prentice Hall inc. 1984.

REFERENCE BOOKS

1. Self tuning and Adaptive control, Harris C.J. Billings. S.A., Peter pereginius Ltd., 1984.
2. Digital Control System vol. I & II, Isermann R, Narosa Publishing House, Reprint 1993.
3. Discrete Technique of Parameter Estimate, Mendal JM, Marcel dekkas, New York, 1973.

EE 912 ADVANCED DIGITAL SIGNAL PROCESSING

UNIT-I: DISCRETE TIME SIGNALS

Introduction to Discrete time signals LTI system-stability-properties-sampling-frequency domain Representation of discrete time signals and systems –Discrete random signals.Z-transforms – properties – inverse Z transforms.

UNIT-II: DIGITAL FILTER DESIGN

Design of IIR filter – filter structures – Design from analog filter; Design of FIR filters - structures – windowing - Design examples.

UNIT-III: ADAPTIVE DIGITAL FILTERS

Adaptive filters – Examples of Adaptive filtering – The minimum mean square error criterion; The Widrow and Hoff LMS Algorithm – Recursive least square Algorithm – Applications

UNIT-IV: APPLICATION OF SAMPLING RATE ALTERATION

The basic sample rate Alteration Devices-Filters with sampling rate Alteration systems – Multistage Design of Decimators and Interpolators – Arbitrating rate sampling rate converter –Polyphase decomposition – digital filter design - Application.

UNIT-V: DIGITAL SIGNAL PROCESSORS

Digital signal processors – Introduction DSP processor memory Architecture – some example of DSP processors – pipelining - overview of TMS 320 family DSP processor –First generations TMS 320eix to sixth generation TMS 320cbx processor.

TEXT BOOKS

1. Digital signal processing: A Computer Based Approach, Sanjit K. Mitra, Tata McGraw hill Pub. Company Limited New Delhi, 2001.
2. Digital Filters: Analysis, Design and Application. Andreas Antoniou, Tata McGraw hill Pub. Company Limited New Delhi, 2001.

REFERENCE BOOKS

1. Digital signal processing, Alan Oppenheim. V and Ronals W. Schafer, Prentice Hall of India Private Limited, New Delhi, 1992.
2. Signals and systems, Simon Haylaim and Barry van veen, John wiley and sons India, 1998.
3. Digital signal processing, S.Salivahanan, Tata Mc Graw Hill Education Private Limited, New Delhi, 2010.

EE 913 DIAGNOSIS AND PROTECTION FOR SOLID STATE SYSTEMS

UNIT-I: PROTECTION AND FAULT DIAGNOSIS OF CONVERTER SYSTEMS

Protections to SCR based power conversion systems: devices, converters – naturally commutated converters – single and three phase converters – dual converters – cyclo-converters - higher pulse converters – forced commutated choppers/inverters.

Fault diagnosis of converters: device failures - commutation failures – phase failures; Fault diagnosis of control loops: failure of controller and limiters, sensor and reference, starting and braking.

UNIT-II: PROTECTION AND DIAGNOSIS OF SOLID STATE DEVICES IN POWER SYSTEMS

Protections to solid state compensators/voltage regulator – TCR, TCS, SVC, TCSC, UPFC, solid state tap changer; Fault diagnosis through waveform/performance analysis of device failures, phase failures, sensor failures; Protection and fault diagnosis of filter — aging of passive components and detuning – auto tuning methods.

UNIT-III: PROTECTION AND FAULT DIAGNOSIS OF SOLID STATE DC DRIVES

Protections to solid state DC drives – field failures, armature failures, commutator short/open, operations with converter/chopper failures – device, input source, filter component failures.

Closed loop control failures – failure of controllers and limiters, sensor and references. Diagnosis of solid state dc drive systems faults - starting and braking.

UNIT-IV: PROTECTION AND DIAGNOSIS OF SOLID STATE AC DRIVES

Protection to AC Machines - phase failures, slip-ring/brush failures, bearing failures; Effects of solid state converter/inverter systems failures of device, PWM modulators, input source, filter components - voltage/current ripple effects, closed loop failures: failure of controller – sensor - references. Diagnosis of solid state ac drive systems faults.

UNIT-V: PROTECTION AND DIAGNOSIS OF HVDC, UPS AND EXCITATION SYSTEMS

Protection and faults in HVDC, UPS, Generator excitation systems: individual systems, multiple systems operating in parallel/series – redundancy - diagnosis of faults through characterization. Analysis of simple faults in complex solid state systems.

TEXT BOOKS

1. Power Electronics, Mohan, Underland and Robbins, John Wiley &Sons, 1995.
2. Pulse Width Modulation for Power Converters: Principles and Practice, D. Grahame Holmes, Thomas A. Lipo, Wiley-IEEE Press, Year.
3. Self-Commutating Converters for High Power Applications, Jos Arrillaga, Yonghe H. Liu, Neville R. Watson, Nicholas J. Murray, John Wiley & Sons, 2009.
4. Modern Power Electronics and AC Drives, Bimal K.Bose, Pearson Education (Singapore) Ltd., New Delhi, 2003.
5. Facts Controllers in Power Transmission and Distribution, K.R.Padiyar, New Age International (P) Limited, New Delhi, 2007.

REFERENCE BOOKS

1. Introduction to Modern Power Electronics, Andrzej M. Trzynadlowski, John Wiley & Sons, 2010.
2. Thyristor-Based FACTS Controllers for Electrical Transmission Systems, R. Mohan and R.K.Varma, IEEE Press – A John Wiley and Sons, Inc. Publications. Year.
3. High-Power Converters and AC Drives, Bin Wu, Wiley-IEEE Press.

4. HVDC and FACTS Controller: Application of Static Converters in power systems, Vijay K. Sood, IEEE Power Electronics and Power Systems series, Kluwer Academic publishers, Boston, 2004.
5. Vector Control of Three-Phase AC Machines: System Development in the Practice, Nguyen Phung Quang, Jörg-Andreas Dittrich, Springer, 2008.

REFERENCES ***(for assignment and class discussion only)***

1. Two recent references to be adopted from high standard research journals for each units of this course.

EE 914 EMBEDDED SYSTEMS

UNIT-I: INTRODUCTION TO EMBEDDED SYSTEMS

Introduction to embedded system -Definition and Classification – Overview of Processors and hardware units in an embedded system – Software embedded into the system – Exemplary Embedded Systems – Embedded Systems on a Chip (SoC).

UNIT-II: EMBEDDED SYSTEM ARCHITECTURE

Microcontroller Architecture - Motorola 68HC11- PIC- Memory System Architecture -Caches - Virtual Memory - Memory Management Unit and Address Translation - I/0 Sub-system - Busy-wait I/0 - DMA - Interrupt driven I/0 -Co-processors and Hardware Accelerators - Processor Performance -Enhancement - Pipelining -Super-scalar Execution.

UNIT-III: EMBEDDED COMPUTING PLATFORM

CPU Bus - Bus Protocols - Bus Organization - Memory Devices and their Characteristics - RAM ROM, UVROM, EEPROM, Flash Memory - DRAM - I/O Devices - Timers and Counters -Watchdog Timers - Interrupt Controllers - DMA Controllers.

UNIT-IV: REAL TIME OPERATING SYSTEMS

Definitions of process, tasks and threads – I/O Subsystems – Interrupt Routines Handling in RTOS - RTOS Task scheduling models - Handling of task scheduling and latency and deadlines as performance metrics – Co-operative Round Robin Scheduling – Case Studies of Programming with RTOS.

UNIT-V: VALIDATION AND TESTING OF EMBEDDED SYSTEMS

A/D and D/A Converters - Displays - Keyboards - Infrared devices - Component Interfacing - Memory Interfacing - I/O Device Interfacing - Interfacing Protocols - Implementation - Development Environment -Debugging Techniques - Manufacturing and Testing.

TEXT BOOKS

1. Embedded Systems Architecture, Programming and Design, Rajkamal, TATA McGraw-Hill, First reprint Oct. 2003.
2. Embedded Systems Design, Second Edition, Steve Heath, Elsevier India Pvt.Ltd.,2007.

REFERENCE BOOKS

1. Introduction to Embedded systems, Shibu K V, Tata McGraw Hill First print - 2009.
2. An Embedded Software Primer, David E.Simon, Pearson Education Asia, First Indian Reprint 2000.
3. Embedded Systems Design – A unified Hardware /Software Introduction, Frank Vahid and Tony Givargis, John Wiley, 2002.
4. Computers as Components; Principles of Embedded Computing System Design Wayne Wolf, Harcourt India, Morgan Kaufman Publishers, First Indian Reprint 2001.

EE 915 FPGA BASED SYSTEM DESIGN

UNIT-I: INTRODUCTION

Programmable Logic Devices-Types-PLA, PAL, FPGA-architectures, SRAM-based FPGAs, Permanently Programmed FPGAs, Chip I/O. Circuit Design of FPGA Fabrics. Architecture of FPGA Fabrics.

UNIT-II: FPGA-BASED SYSTEMS AND VLSI TECHNOLOGY

Introduction, Basic Concepts, Digital Design and FPGAs. FPGA-based system design.

Manufacturing Processes, Transistor Characteristics, CMOS Logic Gates, Wires, Registers and RAM, Packages and Pads.

UNIT-III: COMBINATIONAL LOGIC

The Logic Design Process. Hardware Description Languages, combinational network delay. Power and energy optimization, arithmetic logic, logic implementation for FPGAs. Physical Design for FPGAs. The Logic Design Process.

UNIT-IV: SEQUENTIONAL MACHINES

The sequential machine design process. Sequential design styles. Rules for Clocking. Performance Analysis. Power Optimization.

UNIT-V: LARGE SCALE SYSTEMS

Architectures and Large Scale Systems, Behavioral Design, Design Methodologies. Design Example.Busses, Platform FPGAs, Multi-FPGA Systems, Novel Architectures.

TEXT BOOKS

1. FPGA-Based System Design", Wayne Wolf, Prentice Hall, 2004.
2. Modern VLSI Design, Wayne Wolf, Pearson Education 2002.

REFERENCE BOOKS

1. Advanced Digital Design with verilog HDL, Michael D Ciletti, Pearson Education 2005
2. Verilog HDL, Samir Palnitkar, Pearson Education 2005.
3. A Verilog HDL Primer, J Bhaskar, 2nd edition, B S Publications, 2007.
4. VHDL for Programmable Logic, Kevin Skahill Pearson Education, 2004

EE 916 FUZZY CONTROL

UNIT-I: INTRODUCTION

Crisp Sets, Fuzzy Sets, Linguistic Variables, Values and Rules, Rule Base, Fuzzification, Membership Functions-Types, Inference Mechanism, Defuzzification, Takagi-Sugeno Fuzzy Systems.

UNIT-II: FUZZY CONTROL

Conventional Control System- Design. Fuzzy control system- choice of controller inputs and outputs, rule base using control knowledge, fuzzy quantification of knowledge, rule determination, converting decisions into actions.

UNIT-III: DESIGN EXAMPLES OF FUZZY CONTROL

The inverted pendulum-scaling-tuning membership functions-basic design guidelines, real time implementation issues-computational time, memory requirements, typical design example.

UNIT-IV: NONLINEAR ANALYSIS, IDENTIFICATION AND ESTIMATION

Parameterized fuzzy controllers, fuzzy-P, PI, PID controllers, Lyapunov stability analysis-direct and indirect.

Fuzzy identification, estimation- fitting functions to data, least squares method, gradient methods, clustering methods, and extraction of rules from data.

UNIT–V: ADAPTIVE AND SUPERVISORY FUZZY CONTROL

Fuzzy model reference learning control (FMRLC)-reference model, fuzzy controller, learning mechanism, knowledge based modifiers, design and implementation, case study.

Supervision of fuzzy controllers, tuning, gain scheduling, supervision of fuzzy control-rule based supervision-case study.

TEXT BOOKS

1. Fuzzy Control, Kevin M. Passino and Stephen Yurkovich, Addison Wesley, 1998.
2. Fuzzy logic with Engineering Applications, Timothy J.Ross, John Wiley & Sons, 2010.

REFERENCE BOOKS

1. A Course in Fuzzy Systems and Control, Li-Xin Wang, Prentice Hall PTR, 1997.
2. Essentials of Fuzzy Modeling and Control, R.K. Yager, D.P.Filev, John Wiley & Sons inc, New York, 1994.
3. Fuzzy Sets and Fuzzy Logic: Theory and Applications, Klir G.J and B.O.Yuan, PHI, India, 1997.
4. An Introduction to Fuzzy Control, Dimiter Driakov et al, Narosa Publication House, 1993.

EE 917 MODERN POWER ELECTRONIC CONVERTERS

UNIT-I: SWITCHED MODE POWER SUPPLIES (SMPS)

DC Power supplies and Classification; Switched mode dc power supplies - with and without isolation, single and multiple outputs; Pump circuits - developed, transformer type and super lift pumps; Luo converters - positive, negative and double output; SEPIC converter. Voltage-lift converters and Super lift converters - types and basic circuit operation. Closed loop control and regulation; Design examples on converter and closed loop performance.

UNIT-II: AC-DC CONVERTERS

Switched mode ac-dc converters – synchronous rectification - single and three phase topologies - switching techniques - high input power factor – reduced input current harmonic distortion – improved efficiency – with and without input-output isolation – performance indices – closed loop control and regulation – design examples - Multi-converter systems – redundancy, reliability.

UNIT-III: DC-AC CONVERTERS

Multi-level Inversion - concept, classification of multilevel inverters, Principle of operation, main features and analysis of Diode clamped, Flying capacitor and cascaded multilevel inverters; Modulation schemes, waveforms and harmonic content; Comparison of topologies – device stress, losses, component count and dc link voltage balancing. Z - Source converters; Active filters – topologies, operation and closed loop control.

UNIT-IV: AC-AC CONVERTERS WITH AND WITHOUT DC LINK

Matrix converters – Basic topology of matrix converter; Commutation - current path; Modulation techniques - scalar modulation, indirect modulation; Matrix converter as only ac-dc converter; Vienna Rectifier – Principle of operation, main features and analysis, types and applications

AC-AC converter with DC link - topologies and operation - with and without resonance link - converter with dc link converter; Performance comparison with matrix converter with DC link converters.

UNIT-V: SOFT-SWITCHING POWER CONVERTERS

Power electronic converters – analysis and determination of power losses – loss reduction techniques; Soft switching techniques – ZVS, ZCS, ZVT, quasi resonance operation; Performance comparison hard switched and soft switched converters – ac-dc converter, dc-dc converter, dc-ac converter – ac-ac converter; Resonant dc power supplies - bidirectional power supplies; Introduction to concept of integrated topologies.

TEXT BOOKS

1. Power Electronics Handbook, M.H.Rashid, Academic press, Newyork, 2000.
2. Advanced DC/DC Converters, Fang Lin Luo and Fang Lin Luo, CRC Press, New York, 2004.
3. Control in Power Electronics- Selected Problem, Marian P.Kazmierkowski, R.Krishnan and Frede Blaabjerg, Academic Press (Elsevier Science), 2002.

REFERENCE BOOKS

1. Power Electronic Circuits, Issa Batarseh, John Wiley and Sons, Inc.2004.
2. Power Electronics for Modern Wind Turbines, Frede Blaabjerg and Zhe Chen, Morgan & Claypool Publishers series, United States of America, 2006.
3. Wind and Solar Power Systems, Mukund R.Patel, CRC Press, New York, 1999.
4. Power Electronics: Converters, Applications, and Design, 3rd edition, Jai P Agarwal, Prentice Hall,2000

5. Johann W. Kolar, Uwe Drofenik, and Franz C. Zach, "VIENNA Rectifier II—A Novel Single-Stage High-Frequency Isolated Three-Phase PWM Rectifier System", IEEE Transactions on Industrial Electronics, vol.46, no.4, pp.674-691, August 1999.

REFERENCES ***(for assignment and class discussion only)***

1. Two recent references to be adopted from high standard research journals for each units of this course.

EE 918 NEURAL NETWORKS

UNIT-I: INTRODUCTION

Introduction – Biological neural network – Artificial Neural network – comparison, motivation and Development. Neuron model – single / multiple inputs, transfer functions. Network architecture – single / multiple layers – Recurrent networks

Perceptron network – architecture, learning rule, linear seperability limitation.

UNIT-II: SUPERVISED LEARNING

Learning mechanism – supervised learning – multiplayer perceptrons for pattern classification and function approximation. The back propagation algorithm – numerical examples. Drawbacks in Back propagation – Momentum method, variable learning rate, Levenburg Marguardt Algorithm. Other supervised learning methods – supervised Hebbs rule, Widrow Hoff learning rule – Adaline network.

UNIT-III: ASSOCIATIVE NETWORKS

Associative learning – unsupervised Hebb's rule – Instar learning rule – Kohonen rule, Outstar rule – Pattern association – Hetero associative, Auto associative and Bi-directional associative memory – Discrete Hopfield network – Architecture, algorithm.

UNIT-IV: COMPETITIVE & SELF ORGANIZING NETWORKS

Competitive networks – Fixed weight competitive network – Kohonen Self organizing maps – architecture, algorithm – Learning vector quantisation – architecture, algorithm.

Adaptive resonance theory – ART1; architecture, algorithm

UNIT-V: APPLICATIONS TO ELECTRICAL DRIVES AND CONTROL

Modelling – Space vector modulator, Estimation- Motor speed, flux , torque.

Filtering using Neural Networks. Choice of Neural architectures and training algorithms for the various applications.

TEXT BOOKS

1. Neural Network Design – Martin T. Hagam, Howard B.Demuth and Mark Beale, Thomson learning 2002.
2. Fundamentals of Neural Networks-architecture, algorithm and application – Laurene Faseff, Pearson Education 2004.
3. Modern Power Electronics and AC Drives, Bimal K.Bose, Pearson Education (Singapore) Ltd., New Delhi, 2003.

REFERENCE BOOKS

1. Neural Networks-algorithms, applications and programming techniques – James A.Freemen and David M.Skapura, Addison Wesley Publishing House 1992
2. Artificial Neural Network – Robert J.Schalfoll, Tata McGraw Hill Co, 1997.
3. Neural Network – Sathis kumar, Tata McGraw Hill 2004
4. Neural Networks: A Comprehensive Foundation - Simon Haykin, Prentice Hall of India, 2008.
5. Neural Network Design - Martin T. Hagan, Howard B. Demuth, Mark H. Beale, Thomson Learning, 1995.

EE 919 NONLINEAR CONTROL SYSTEMS

UNIT-I: PROPERTIES OF NONLINEAR SYSTEMS:

Basic mathematical and structural models of nonlinear systems – basic properties of nonlinear systems - Stability and Equilibrium States – basic properties of nonlinear functions - Typical Nonlinear Elements – basic nonlinearity classes.

UNIT-II: STABILITY

Equilibrium States and Concepts of Stability - Stability of a Nonlinear System Based on Stability of the Linearized System - Lyapunov Stability - Definitions of Stability - Lyapunov Direct Method - Absolute Stability of Equilibrium States of an Unforced System (Popov Criterion) - Geometrical Interpretation of Popov Criterion - Absolute Stability with Unstable Linear Part - Absolute Stability of an Unforced System with Time-Varying Nonlinear Characteristic - Absolute Stability of Forced Nonlinear Systems

UNIT-III: LINEARIZATION METHODS

Graphical Linearization Methods - Algebraic Linearization - Analytical Linearization Method - Evaluation of Linearization Coefficients by Least-Squares Method - Harmonic Linearization - Describing Function - Statistical Linearization - Combined (Dual-Input) Describing Functions

UNIT-IV: PHASE TRAJECTORIES

Operating Modes of Nonlinear Control Systems - Self-Oscillations - Forced Oscillations - Effects of High-Frequency Signal-Dither - Methods of Dynamic Analysis of Nonlinear Systems - Phase Plane - Phase Trajectories of Linear and Non linear Systems - Methods of Defining Phase Trajectories - Examples of Application of Various Methods to obtain Phase Trajectories

UNIT-V: DYNAMIC ANALYSIS OF NON-LINEAR CONTROL SYSTEMS

Harmonic Linearization in Dynamic Analysis of Nonlinear Control Systems Operating in Stabilization Mode **-** Describing Function in Dynamic Analysis of Unforced Nonlinear Control Systems - Analysis of Symmetrical Self-Oscillations - Determination of Symmetrical Self-Oscillations - Asymmetrical Self-Oscillations- Forced Oscillations of Nonlinear Systems - Resonance Jump - Harmonic Linearization in Dynamic Analysis of Nonlinear Control Systems in Tracking Mode of Operation

TEXT BOOKS

1. Nonlinear Systems Analysis, Stability and Control, Shankar Sastry, Springer, USA, 1999.
2. Nonlinear systems, Hassan K. Khalil, Prentice Hall, 2001.

REFERENCE BOOKS

1. Nonlinear system analysis, M. Vidyasagar, SIAM, 2002.
2. Nonlinear Control Systems, Zoren Vukic, Ljubomir Kuljaca, Dali Donlagic and Sejid Tesnjak, Marcel Dekker Inc, USA, 2003.

EE 920 OPTIMAL CONTROL THEORY

UNIT-I: PERFORMANCE MEASURE

Problem formulation - state variable representation of systems - performance measures for optimal control problems - selecting a performance measure.

UNIT-II: DYNAMIC PROGRAMMING

Optimal control law – principle of optimality – Application of Principle of optimality to decision making – Recurrence relation of Dynamic Programming – Imbedding Principle – computational procedure to solve optimal control problems – Discrete Linear regulator Problems – Hamilton – Jacobi Belman Equation – Continous linear regulator problems

UNIT-III: CALCULUS OF VARIATIONS:

Fundamental concepts – Functional of a single function – functionals involving several independent functions – piece wise smooth extremals – constrained extrema.

UNIT-IV: VARIATIONAL APPROACH TO OPTIMAL CONTROL PROBLEM

Necessary condition for optimal control – Linear regulator problems – Pontryagin's Minimum Principle and state inequality constraints – Minimum time Problems – Minimum Control – Effort problems – Singular intervals in optimal control Problem.

UNIT-V: NUMERICAL METHODS OF OPTIMAL CONTROL

Simplex Method – golden section Method – Hill climbing – Gradient – Penalty functions methods.

TEXT BOOKS

1. Optimal Control Theory, an Introduction, Donald.E.Kirk, Prentice Hall, Inc., Englewood Cliffs, New Jersey, 1962.
2. Optimal control, Brain D. O. Anderson and J. B. Moore, Prentice Hall, 1990.

REFERENCES BOOKS

1. Optimum Systems Control, Andrew P. Sage, Prentice Hall N.H. 1968
2. Optimal control, Michael Athans and Peter L Falb, Dover publications, 2006.
3. Optimization Theory and Application, Rao S.S. Wiley Eastern, New Delhi, 1992.

EE 921 POWER ELECTRONICS IN POWER SYSTEMS

UNIT-I: REACTIVE POWER REQUIREMENTS

Power system components – representation of single line diagram – uncompensated lines - compensators types and characteristics - conventional compensator - modern compensator - shunt compensator – series compensator - principles of reactive power control – introduction on load compensation - line compensation – P and Q control -phase angle regulation.

Compensator requirements for solid state converters – determination of input power factor and harmonics for various converters – power factor improvement using Load and forced commutated converters.

UNIT-II: REACTIVE POWER COMPENSATION AND REGULATION

Load compensation- voltage regulation - power factor correction - phase balance unsymmetrical loads.

Line compensations – increased power transfer capability – stability and transient limit – losses – harmonics - sub synchronous oscillations - mitigations.

UNIT-III: STATIC COMPENSATORS AND COMPONENTS

Introduction to conventional compensators - – synchronous condenser - saturable core reactor – analysis and design of static compensators - TCR – TSC – SVC – TCSC – modeling and control of static compensators

UNIT-IV: DESIGN OF UPFC AND STATIC TAP CHANGERS

UPFC components – shunt devices - series devices – operation and control – real and reactive power – UPFC parameters and design philosophy.

Conventional tap changing methods – solid state tap changer – voltage regulation - different schemes – comparison – specifications – design methods.

UNIT-V: HVDC AND STATIC GENERATOR EXCITATION SYSTEMS

HVDC components - kinds of DC links – modern HVDC converters - commutation issues - control characteristics – constant phase angle control – constant current and extinction angle control - twelve and higher pulse operation - introduction to modern converters – protections - reactive power requirements – harmonics – filter types and design of various ac and dc filters.

Solid state excitation of synchronous generators – different schemes - Generrex excitation systems – redundancy and reliability.

TEXT BOOKS

1. Reactive power control in Electric systems, Miller.T.J.E, Wiley interscience, New York, 1982.
2. Thyristor-Based FACTS Controllers for Electrical Transmission Systems, R. Mohan and R.K.Varma, IEEE Press – A John Wiley and Sons, Inc. Publications. 2002.
3. HVDC Power Transmission Systems Technology and System Interactions, K. R. Padiyar, New Age International (p) Limited, New Delhi, 2003.

REFERENCES

1. HVDC and FACTS Controller: Application of Static Converters in power systems, Vijay K. Sood, IEEE Power Electronics and Power Systems series, Kluwer Academic publishers, Boston, 2004.
2. Understanding FACTS, Narani.G.Hingorani and Laszlo Gyugyi, IEEE Power Engineering society sponsor, IEEE Press. 2000.
3. Facts Controllers in Power Transmission and Distribution, K.R.Padiyar, New Age International (P) Limited, Publishers, New Delhi, 2007.
4. “Static Compensator for AC power systems”, Proc. IEE vol.128 Nov. 1981. pp 362- 406.

5. “A Static alternative to the transformer on load tap changing”, IEEE Trans. On Pas, Vol.PAS-99, Jan. /Feb. 1980, pp86-89.
6. “Improvements in Thyristor controlled static on- load tap controllers for transformers”, IEEE Trans. on PAS, Vol.PAS-101, Sept.1982, pp3091-3095.
7. “Shunt Thyristor rectifiers for the Generrex Excitation systems”, IEEE Trans. On PAS. Vol.PAS -96, July/August, 1977, pp1219-1225.

EE 922 POWER QUALITY

UNIT-I: INTRODUCTION

Introduction -Characterization of Electric Power Quality: Transients, short duration and long duration voltage variations, Voltage Imbalance, waveform distortion, Voltage fluctuations, Power frequency variation, Power acceptability curves - 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

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

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

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-V: POWER QUALITY IMPROVEMENT

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.

TEXT BOOKS

1. Power Quality Enhancement Using Custom Power Devices, Arindam Ghosh, Gerard Ledwich, Kluwer Academic Publishers, 2002.
2. Electric Power Quality, G.T.Heydt, McGraw-Hill Professional, 2007.

REFERENCE BOOKS

1. Electrical Power Systems Quality, Roger C. Dugan, Mark F. McGranaghan, Surya Santos, H. Wayne Beaty ,McGraw Hill, New Delhi 2003.
2. Power electronic converter harmonics, Derek A. Paice, IEEE Press, 1996.
3. Power Quality, C.Sankaran, CRC Press, 2002.
4. Power system harmonics -A.J. Arrillga, Neville.R.Watson, John Wiley Publishers, 2002.
5. Understanding Power Quality Problems, Math H. Bollen, IEEE Press, 2000.
6. Power System Quality Assessment, J. Arrillaga, John wiley, 2000.

EE 923 RENEWABLE ENERGY ELECTRICAL SYSTEMS

UNIT-I: FUNDAMENTALS OF WIND AND TIDAL POWER

Introduction to renewable energy sources: wind – wave – tidal. Principle of energy conversion systems: wind - wave – tidal. History of renewable energy based electrical power generation.

Wind energy conversion devices - aerodynamics – design of rotor – performance curves – turbine control - efficiency– wind speed and direction measurement – wind speed distribution - other modern developments - future possibilities – wind energy scenario.

UNIT-II: WIND ELECTRICAL ENERGY CONVERSION SYSTEMS

Grid-connected systems: types of generators – induction generator - equivalent circuit – efficiency – single phase operation of 3-phase induction generators – permanent magnet generator – synchronous generator - different conversion schemes– fixed and variable speed operation – drive selection – power control – braking systems - grid integration issues.

Stand-alone systems: self-excitation process – effect of excitation capacitance – equivalent circuit – voltage and frequency control techniques - power flow studies – applications.

UNIT-III: WIND FARM

Site selection - planning of wind farms - maintenance and operation - environmental assessment - electrical design - power collection systems - earthing – electrical protection – power quality issues – reactive VAR isues – compensators - remote monitoring and control - economic aspects - micro wind systems.

UNIT-IV: PV TECHNOLOGY

Solar radiation - photo voltaic effect - types of PV cells – electrical properties – equivalent circuit - cell characteristics - effects of temperature variation, insolation level and tilt angle – peak power point operation - PV cell model - PV module - design options – site survey and shading analysis - array configurations - economics - environmental issues.

UNIT-V: GRID CONNECTED AND STAND-ALONE PV SYSTEMS

Grid connected systems: Technical and non-technical considerations - system size and module choice - mounting systems and building integration- power conditioning system - lightning protection - earthing - metering – Simulation of grid-connected system.

Stand-alone systems: Modules – Batteries – charge controllers –stand-alone inverters- sizing of PV arrays – applications (telecommunication, electricity for rural areas, water pumping, other applications) – Hybrid energy systems.

TEXT BOOKS

1. Wind electrical systems, S.N.Bhadra, D.Kastha and S. Banerjee, Oxford University Press, 2005.
2. Wind and Solar Power Systems, Mukund R. Patel, CRC Press, 1999.

REFERENCE BOOKS

1. Planning and Installing Photovoltaic Systems, Deutsche Gesellshaft Fur Sonnenergie (DGS), Second Edition, Earthscan Publishers, 2008.
2. Wind Energy Systems for Electrical Power Generation, Manfred Stiebler, Springer, 2008.
3. Wind Energy System, Gary L. Johnson, Prentice hall Inc., Englewood Cliffs, New Jersey, 1985.
4. Wind energy conversion system, L. Lfreris, Prentice hall (U.K) Ltd., 1990.

5. Solar Electricity: Engineering of Photovoltaic systems, E. Lorenzo , Earthscan Publications Ltd, 1994.
6. Photovoltaic systems Engineering, Roger A Messenger and Jerry Ventre, second edition, CRC Press, 1997.

EE 924 SPECIAL ELECTRICAL MACHINES

UNIT-I: SINGLE PHASE MACHINES

Principles and construction of split phase motors – Shaded pole motor – Repulsion motor - Universal motor – Unexcited synchronous single phase motor – Reluctance and Hysteresis motor – Schrage motor - Applications.

UNIT-II: STEPPER MOTORS

Constructional features - Principle of operation - Modes of excitation – Types of motors – Drive systems and circuit for control of Stepper motor – Applications Dynamic characteristics.

UNIT-III: SWITCHED RELUCTANCE MOTORS

Constructional features - Principle of operation - Torque prediction - Power controllers - Characteristics and control - Applications.

UNIT-IV: PERMANENT MAGNET BRUSHLESS DC MOTORS

Commutation in DC motors - Difference between mechanical and electronic commutators - permanent magnet brushless motor drives - Torque and Emf equation; Torque-Speed characteristics; Sensors - Controllers; Applications.

UNIT-V: THREE PHASE AC MACHINES

Principle of operation - Constructional features of Permanent Magnet synchronous motor- torque expressions - Phasor diagram - characteristics - Vector control - Applications.

Principle and construction of Doubly Fed Induction generator- characteristics-control-Application in wind farm – merits and demerits

TEXT BOOKS

1. Brushless Permanent Magnet and Reluctance Motors Drives, T.J.E. Miller, Clarendon Press, Oxford, 1989.
2. Permanent Magnet Brushless DC Motors, T. Kenjo and S.Negamori, Clarendon Press, Oxford, 1989.

REFERENCE BOOKS

1. Stepping Motors, A Guide to Modern Theory and Practice, P.P. Acarnley, Peter Peregrinus, London, 1990.
2. Electric Motors and Drives, A. Hughes, Affiliated East-west Pvt., Ltd., Madras, 1990.
3. Stepping Motors and their Microprocessor Control, Kenjo, Clarendon Press, Oxford, 1989.
4. Electrical Machines, I.J.Nagrath & D.P.Kothari, Tata McGraw Hill, 1999.
5. Distributed Generation: Induction and Permanent Magnet generators, Loi Lei Lai, Tze Fun Chan, Wiley Publishers, 2007
6. Electrical Technology, vol-II, AC & DC Machines, B.L.Theraja, A.K.Theraja, S.Chand & Company Ltd., 2005.