HINDUSTAN
INSTITUTE OF TECHNOLOGY & SCIENCE
(DEEMED TO BE UNIVERSITY)

DEPARTMENT OF
ELECTRICAL AND ELECTRONICS ENGINEERING

Regulations Curriculum
and Syllabus
2013
Semester I -IV

M.Tech.
(POWER ELECTRONICS & DRIVES)

M.Tech. (POWER ELECTRONICS AND DRIVES)

Objective of the Programme:

To get an insight in to the theoretical and application aspects of various areas of Power Electronics and Drives including Devices, Converters, Inverters, Solid state drives, system theory, simulation, embedded control etc., This programme will enable the students to pursue further academic work or research and development in this field.

SEMESTER I

Sl. No.	Course Code	Course Title	L	T	P	C	TCH
Theory							
1	PMA107	Advanced Mathematics for Electrical Engineers*	4	0	0	4	4
2	PPS702	Analysis of Electrical Machines**	3	1	0	4	4
3	PPD102	Advanced Power Semiconductor Devices	3	1	0	4	4
4	PPD103	Analysis of Power Converters	3	1	0	4	4
5	PPD104	Analysis of Inverters	3	1	0	4	4
6	PPD105	Special Electrical Machines	3	1	0	4	4
		Total				**24**	**24**

***Common to M Tech(PSE)& M Tech(ELS)**

** **Common to M Tech(PSE)**

SEMESTER II

Sl. No.	Course Code	Course Title	L	T	P	C	TCH
Theory							
1.	PPD201	Computer Aided Design of Electrical Apparatus	3	1	0	4	4
2.	PPD202	Solid State DC Drives	3	1	0	4	4
3.	PPD203	Solid State AC Drives	3	1	0	4	4
4.	PPD204	Linear and Non Linear System Theory **	3	1	0	4	4
5.		Elective - I	3	1	0	4	4
6.		Elective - II	3	1	0	4	4
Practical							

7.	PPD231	Power Electronics & Drives Lab	0	0	3	2	3
Total						**26**	**27**

****Common to M Tech(PSE)**

SEMESTER III

Sl.No.	Course Code	Course Title	L	T	P	C	TCH
Theory							
1	-	Elective - III	3	1	0	4	4
2	-	Elective - IV	3	1	0	4	4
3	-	Elective - V	3	1	0	4	4
Practicals							
4	PPD301	Project - (Phase I)	0	0	12	6	12
		Total				**18**	**24**

SEMESTER IV

Sl.No.	Course Code	Course Title	L	T	P	C	TCH
Practicals							
4	PPD401	Project - (Phase II)	0	0	24	12	24
		Total				**12**	**24**

TOTAL CREDITS : 80

ELECTIVE COURSES

Sl.No.	Course Code	Course Title	L	T	P	C	TCH
1	PCS101	Advanced Digital Signal Processing	3	1	0	4	4
2	PPD701	Embedded Control of Electrical Drives	3	1	0	4	4
3	PPD702	Intelligent Control*	3	1	0	4	4
4	PPD703	Flexible AC Transmission Systems*	3	1	0	4	4
5	PPD705	High Voltage Direct Current Transmission*	3	1	0	4	4
6	PPD706	Power System for Power Electronics	3	1	0	4	4
7	PPD707	Power Quality*	3	1	0	4	4
8	PPS705	Wind Energy Conversion Systems*	3	1	0	4	4
9	PPS707	Energy Auditing and Management*	3	1	0	4	4
10	PPS708	Distributed Energy Resources*	3	1	0	4	4

***Common to M Tech(ELS)& M Tech(PSE)**

PMA107 ADVANCED MATHEMATICS FOR ELECTRICAL ENGINEERS

Common to M Tech(ELS) & M Tech(PSE)

L	T	P	C
4	0	0	4

Objectives

1. To know about probability theory useful for power system
2. To know about dynamic programming For optimization techniques
3. To know about differential calculus

Out come

1. Getting idea about basic fundamentals of probability
2. Getting idea about optimization techniques
3. Getting idea about differential calculus

UNIT I ADVANCED MATRIX THEORY **12**

Matrix norms – Jordan canonical form – Generalized eigenvectors – Singular value decomposition – Pseudo inverse – Least square approximations – QR algorithm.

UNIT II NUMERICAL SOLUTION OF ALGEBRAIC EQUATIONS **12**

Solutions of large systems of equations using Gauss Elimination method; principle behind sparsity and optimal ordering; relevance of the solution technique for engineering applications.

UNIT III NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS **12**

Single and multi – step methods – explicit and implicit methods – advantages of implicit methods – solution of differential algebraic methods encountered in power engineering.

UNIT IV LINEAR PROGRAMMING **12**

Basic concepts – Graphical and Simplex methods –Transportation problem – Assignment problem.

UNIT V DYNAMIC PROGRAMMING **12**

Elements of the dynamic programming model – optimality principle – Examples of dynamic programming models and their solutions.

L : 60 TOTAL : 60

REFERENCES

1. Lewis.D.W., “Matrix Theory”, Allied Publishers,Chennai 1995.
2. Bronson,R, “Matrix Operations”, Schaums outline Series ,McGraw Hill ,Newyork. 1989.
3. L.O.Chua, P.M.Lin, “Computer-Aided Analsis of Electronic Circuits”, Prentice Hall, Englewood Cliffs, New Jersey, 1978.
4. Taha, H.A., " Operations research - An Introduction ", Mac Millan publishing Co., (1982).
5. Gupta, P.K.and Hira, D.S., "Operations Research", S.Chand & Co., New Delhi,1999.

PPS702 ANALYSIS OF ELECTRICAL MACHINES

L	T	P	C
3	1	0	4

Objective

To provide the idea about

1. Electromagnetic energy conversion in various system.
2. Modeling of Stationary circuits in various Reference Frame.
3. Modeling of different Electrical machines.
4. Analysis of machines under Steady state and transient conditions.

Outcome

To get a knowledge about

1. Calculation of MMF and machine inductance
2. State equations and Time domain block diagram
3. Modeling of AC machines and DC machines in various reference frames like arbitrary and Parks Transformation.
4. Analysis under Steady state and transient conditions for different machines.
5. Analyse Dynamic performance with the help of simulation

UNIT I PRINCIPLES OF ELECTROMAGNETIC ENERGY CONVERSION 9

General expression of stored magnetic energy, co-energy and force/ torque - example using single and doubly excited system –AC machines: Calculation of air gap mmf and per phase machine inductance using physical machine data.

UNIT II REFERENCE FRAME THEORY 9

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

UNIT III DC MACHINES 9

Voltage and toque equations - dynamic characteristics of permanent magnet and shunt DC motors – Time domain block diagram and state equations

UNIT IV INDUCTION MACHINES 9

Voltage and toque equations - transformation for rotor circuits - voltage and torque equations in arbitrary reference frame variables - analysis of steady state operation - dynamic performance for load and torque variations - dynamic performance for three phase fault - computer simulation in arbitrary reference frame.

UNIT V SYNCHRONOUS MACHINES 9

Voltage and Torque Equation - voltage Equation in arbitrary reference frame and rotor reference frame- Park equations - rotor angle and angle between rotor - steady state analysis - dynamic performances for torque variations- dynamic performance for three phase fault - transient

stability limit – critical clearing time - computer simulation.

L=45 T=15 TOTAL=60

TEXT BOOK

1.Paul C.Krause, OlegWasyzczuk, Scott S, Sudhoff, "Analysis of Electric Machinery and Drive Systems", IEEE Press, Second Edition.

2.R.Krishnan, "Electric Motor Drives, Modeling, Analysis and Control" , Prentice Hall of India,2002.

REFERENCES

1.Samuel Seely, " Eletomechanical Energy Conversion", Tata McGraw Hill Publishing Company.

2.A.E.Fitzgerald, Charles Kingsley, Jr, and Stephan D, Umanx, " Electric Machinery", TataMcGraw Hill, 5th Edition, 1992.

PPD102 ADVANCED POWER SEMICONDUCTOR DEVICES

L	T	P	C
3	1	0	4

Prerequisite

Power Electronics

Goal

To introduce advanced power semiconductor devices with a focus on fast switching frequency.

Objectives

The subject should enable the students to:

1. Study the key concepts, operation and electrical characteristics of power diodes.
2. Know about the construction and operation of power BJT & SCR.
3. Know about the construction, operation and modelling of Power MOSFET & IGBT.
4. Understand the driving & protection circuits for various power semiconductor devices
5. Study the thermal protection of power semiconductor devices

Outcome

At the end of the subject the student should be able to:

1. Explain the concepts, operation and electrical characteristics of power diodes.
2. Understand about the construction, operation and modelling of Power BJT,SCR,MOSFET & IGBT.
.
3. Explain the structure & switching behavior of MOS-Controlled devices.
4. Design protection and driving circuits for various power semiconductor

5. know how to protect semiconductor devices from heat.

UNIT I INTRODUCTION 9

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

UNIT II CURRENT CONTROLLED DEVICES 9

BJT's - Construction, static characteristics, switching characteristics; Negative temperature co-efficient and secondary breakdown; Power darlington - Thyristors - Physical and electrical principle underlying operating mode, Two transistor analogy - concept of latching; Gate and switching characteristics; converter grade and inverter grade and other types; series and parallel operation; comparison of BJT and Thyristor - steady state and dynamic models of BJT & Thyristor.

UNIT III VOLTAGE CONTROLLED DEVICES 9

Power MOSFETs and IGBTs - Principle of voltage controlled devices, construction, types, static and switching characteristics, steady state and dynamic models of MOSFET and IGBTs - Basics of GTO, MCT, FCT, RCT and IGCT.

UNIT IV FIRING AND PROTECTING CIRCUITS 9

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

UNIT V THERMAL PROTECTION 9

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

L=45, T=15,Total = 60

TEXT BOOKS

1. B.W Williams ' Power Electronics Devices,Drivers and Applications. Wiley, 1987.
2. Rashid M.H., "Power Electronics Circuits, Devices and Applications", Prentice Hall of India, Third Edition,New Delhi, 2004.

REFERENCES

1. MD Singh and K.B Khanchandani, "Power Electronics", Tata McGraw Hill, 2001.
2. Mohan, Undeland and Robbins, "Power Electronics –Converters applications and Design, John Wiley and Sons, Singapore, 2000.

PPD103 ANALYSIS OF POWER CONVERTERS

L	T	P	C
3	1	0	4

Prerequisite

Power Electronics

Goal

To provide knowledge about the structure and functioning of different converter circuits

Objectives

The course will enable the students :

1. To get exposed to the construction, working and performance calculation of various types of single phase converters.
2. To familiarize the students with the working of three phase AC-DC converters with different types of loads.
3. To familiarize the students with the working of DC-DC converters
4. To expose the students to the types of AC voltage controllers
5. To familiarize the students with single phase and three phase cycloconverters

Outcome

After completion of the course the students are expected to be able to:

1. Explain the theory and working of different types of single phase converters.
2. Explain the working of three phase converters for different load conditions
3. Gain knowledge about DC choppers
4. Explain the functioning of various AC voltage controllers
5. Explain the working of single phase and three phase cycloconverters

UNIT I SINGLE PHASE AC-DC CONVERTER 9

Uncontrolled, half controlled and fully controlled converters with R-L, R-L-E loads and free wheeling diodes - continuous and discontinuous modes of operation - inverter operation - Dual converter - Sequence control of converters - performance parameters: harmonics, ripple, distortion, power factor - effect of source impedance and overlap.

UNIT II THREE PHASE AC-DC CONVERTER 9

Uncontrolled and fully controlled - converter with R, R-L, R-L-E - loads and free wheeling diode - inverter operation and its limit - dual inverter - performance parameters - effect of source impedance and overlap.

UNIT III DC-DC CONVERTERS 9

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

UNIT IV ACVOLTAGE CONTROLLERS 9

Principle of phase control: single phase and three phase controllers - various configurations - analysis with R

and R-L loads – Applications of AC voltage controller.

UNIT V CYCLOCONVERTERS 9

Principle of operation - Single phase and three phase cycloconverters - power circuits and gating signals – Applications of cycloconverter.

L=45, T=15,Total =60

TEXT BOOKS:

1. Ned Mohan, Undeland and Robbins, "Power Electronics: converters, Application and design" John Wiley and sons, Inc, Newyork, 1995.
2. Rashid M.H., "Power Electronics Circuits, Devices and Applications:, Prentice Hall of India, New Delhi, 1995.

REFERENCES:

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

PPD104 ANALYSIS OF INVERTERS

L	T	P	C
3	1	0	4

Prerequisite

Power Electronics

Goal

To provide knowledge about the structure and functioning of inverter circuits

Objectives

The course will enable the students:

1. To get exposed to the construction, working, voltage control and performance calculation of various types of single phase inverters.
2. To familiar the students with the working of three phase voltage source inverters with star and delta loads.
3. To familiar the students with the working of current source inverters
4. To expose the students to the types of multilevel inverters
5. To familiarize the students with resonant inverters and their voltage control.

Outcome

After completion of the course the students are expected to be able to:

1. Explain the theory and working of different types of single phase inverters.
2. Explain the working of three phase inverters for 180 degree and 120 degree conduction modes.

3. Gain knowledge about current source inverters
4. Explain the functioning of working of multilevel inverters and their applications
5. Explain the working of resonant inverters.

UNIT I SINGLE PHASE INVERTERS 9

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

UNIT II THREE PHASE VOLTAGE SOURCE INVERTERS 9

180 degree and 120 degree conduction mode inverters with star and delta connected loads - voltage control of three phase inverters.

UNIT III CURRENT SOURCE INVERTERS 9

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

UNIT IV MULTILEVEL INVERTERS 9

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

UNIT V RESONANT INVERTERS 9

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

L=45, T=15,Total =60

TEXTBOOKS

1. Rashid M.H., "Power Electronics Circuits, Devices and Applications", Prentice Hall of India, Third Edition, New Delhi, 2004.
2. Jan P. Agrawal, "Power Electronics Systems", Pearson Education, Second Edition, 2002.

REFERENCEs

1. P.C. Sen., "Modern Electronics", Wheeler Publishing Co, First Edition, New Delhi, 1998.
2. P.s. Bimbra, "Power Electronics", Khanna Publishers, Eleventh Edition, 2003.
3. Bimal K.Bose, "Modern Power Electronics and AC Drives", Pearson Education, Second Edition, 2003.

PPD105 SPECIAL ELECTRICAL MACHINES

L	T	P	C
3	1	0	4

Prerequisite – Electrical Machines

Goal

To provide the basic principles, control and applications of special electrical machines in industries.

Objectives

The course will enable the students to:

(i) Learn the constructional features, principle of operation ,methods of control and applications of stepper motors.

(ii) Understand the constructional features, principle of operation ,methods of control and applications of Switched reluctance motors.

(iii) Have an insight into the constructional features, principle of operation ,methods of control and applications of PMBLDC motors.

(iv) Have a clear picture of the types, the constructional features, principle of operation ,methods of control and applications of PMSM.

(v) Gain knowledge in the types, the constructional features, principle of operation ,methods of control and applications of SyRM.

Outcome

After completion of the course, the students are expected to:

(i) Realize the need for stepper motors and the various applications in industries.

(ii) Get a clear picture of the operational characteristics and the applications of SRM.

(iii) Know the various types of PMBLDC motors, rotor position sensors ,methods of control and their applications.

(iv) Get a clear idea of the features , control and the applications of PMSM.

(v) Get a clear picture of the operational characteristics and the applications of SyRM.

UNIT I STEPPING MOTORS 9

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

UNIT II SWITCHED RELUCTANCE MOTORS 9

Constructional features, principle of operation, Torque equation, Power Converters and their controllers , Methods of Rotor position sensing , Sensor less operation , Closed loop control of SRM – Characteristics, Microprocessor based controller.

UNIT III PERMANENT MAGNET BRUSHLESS DC MOTORS 9

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

UNIT IV PERMANENT MAGNET SYNCHRONOUS MOTORS 9

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

UNIT V SYNCHRONOUS RELUCTANCE MOTORS 9

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

L=45, T=15,Total =60

TEXT BOOKS

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

REFERENCES

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

PPD201 COMPUTER AIDED DESIGN OF ELECTRICAL APPARATUS

L	T	P	C
3	1	0	4

Prerequisite –Field Theory

Goal

To impart knowledge of formulation and solution of design problems using mathematical and Computational techniques for electrical machines

Objectives

This course should enable the students to:

1. Learn the importance of field analysis based design.
2. Understand the basic electromagnetic field equations and the problem formulation for CAD applications,
3. Become familiar with Finite Element Method as applicable for Electrical Engineering,
4. Know the organization of a typical CAD package,
5. Apply Finite Element Method for the design of different Electrical apparatus.

Outcome

At the end of this course the student should be able to:

1. Understand basics of design considerations for rotating and static electrical machines.
2. Apply vector calculus to understand the behavior of static electric and magnetic fields in standard configurations
3. Understand the mathematical formulation of Finite Difference method and Finite element method.

4. Understand the modules of a typical CAD package.
5. Understand the design procedure of various electrical machines.

UNITI INTRODUCTION 5

Conventional design procedures-Limitations–Main Dimensions and need for field analysis based design of DC and AC machines .

UNITII MATHEMATICAL FORMULATION OF FIELD PROBLEMS 10

Electromagnetic Field Equations –Magnetic Vector/Scalar potential-Electrical vector/ Scalar Potential –Stored energy in electric & magnetic fields- Capacitance -Inductance-Development of torque/force-Laplace and Poisson's Equations-Energy functional-Principle of energy conversion.

UNIT III PHILOSOPHY OF FEM 10

Mathematical models-Differential / Integral equations-Finite Difference method-Finite element method-Energy minimization-Variational method-2D field problems-Discretization-Shape functions-Stiffness matrix-Solution techniques.

UNIT IV CAD PACKAGES

Elements of a CAD system – Pre – processing – Modeling – Meshing –Material Properties boundary Conditions – Setting up solution –Post processing. **10**

UNITV DESIGN APPLICATIONS 10

Design of Induction Motor- Power Transformer- Solenoid Actuator– Inductance and force calculation - Voltage stress in Insulators– Capacitance Calculation.

L= 45 T = 15 TOTAL: 60

TEXTBOOKS:

1. S.JSalon,"FiniteElementAnalysisofElectricalMachines."KluwerAcademicPublishers, London,1995.
2. S.R.H.Hoole,Computer-Aided,AnalysisandDesignofElectromagneticDevices,Elsevier, NewYork,Amsterdam,London,1989.

REFERENCES:

1. P.P.SilvesterandFerrari,"Finite Elements for Electrical Engineers"CambridgeUniversity press,1983.
2. D.A.LowtherandP.PSilvester,"ComputerAidedDesigninMagnetics",Springer Verlag,New York,1986.
3. User Manuals of MAGNET, MAXWELL & ANSYS - Software Packages.

PPD202 SOLID STATE DC DRIVES

L	T	P	C
3	1	0	4

Prerequisite

PPD103 - Analysis of power converters

Goal

To provide knowledge about the fundamentals, operation and design of DC drives with power electronic converter and chopper

Objectives

The course will enable the students to:

(i) Know the basic DC motor fundamentals with their speed-torque relations, mutli-quadrant operation, selection of motor and characteristics of mechanical system

(ii) Give in-depth knowledge in analysis of single and three phase fully controlled converter fed DC motor drive

(iii) Give in-depth knowledge in analysis of chopper fed DC drive

(iv) Give adequate knowledge to model a DC drive with closed loop speed control with various controller

(v) Acquire knowledge about digital control of DC drive

Outcome

At the end of the course the students should be able to

(i) Select the suitable drive for the required load characteristics.

(ii) Understand the concept of Converter / Chopper control of DC motor drive.

(iii) Gain adequate knowledge about DC motor drive and various speed control methods.

(iv) Design controllers for DC drives for open loop and closed loop speed control

(v) Gain adequate knowledge about digital control of DC drive

UNIT I DC MOTORS FUNDAMENTALS AND MECHANICAL SYSTEMS 9

DC motor- Types, induced emf, speed-torque relations; Speed control - Armature and field speed control; Ward Leonard control - Constant torque and constant horse power operations.

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

UNIT II CONVERTER CONTROL 9

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

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

UNIT III CHOPPER CONTROL **9**

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

UNIT IV CLOSED LOOP CONTROL **9**

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

UNIT V DIGITAL CONTROL OF D.C DRIVE **9**

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

L = 45 T = 15 TOTAL = 60

TEXT BOOKS

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

REFERENCES

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

PPD203 SOLID STATE AC DRIVES

L	T	P	C
3	1	0	4

Prerequisite – Power Electronics

Goal

To provide knowledge about the control of AC Drives

Objectives

The course will enable the students:

- To get exposed to the control of induction machine by various methods.
- To know about voltage source and current source inverter fed induction machine and its operational characteristics.

(iii) To familiarize thestudents with the direct and indirect field control method of induction machine.

(iv) To expose the students to the Direct torque control of induction machine.

(v) To familiarize the students with brush and brushless excitation in synchronous motor control.

Outcome

After completion of the course the students are expected to be able to:

(i) Calculate the performance of the induction motor by different conventional control methods.

(ii) Explain the compensation methods for CSI and VSI fed induction machine.

(iii) Gain knowledge about field oriented control of induction machine.

(iv) Explain the direct torque control of induction machine.

(v) Explain the synchronous motor control.

UNIT I CONVENTIONAL CONTROL OF INDUCTION MOTORS 9

Review of Induction Machine operation - Equivalent circuit - Performance of the machine with variable voltage, rotor resistance variation, pole changing and cascaded induction machines, slip power recovery - Static Kramer Drive.

UNIT II VSI AND CSI FED INDUCTION MOTOR CONTROL 9

AC voltage controller fed induction machine operation - Energy conservation issues - V/f operation theory - requirement for slip and stator voltage compensation. CSI fed induction machine - Operation and characteristics.

UNIT III ORIENTED CONTROL 9

Field oriented control of induction machines - Theory - DC drive analogy - Direct and Indirect methods - Flux vector estimation.

UNIT IV DIRECT TORQUE CONTROL 9

Direct torque control of Induction Machines - Torque expression with stator and rotor fluxes, DTC control strategy.

UNIT V SYNCHRONOUS MOTOR CONTROL 9

Synchronous motor control - Brush and Brushless excitation - Load commutated inverter fed drive.

L = 45 T = 15 Total = 60

TEXT BOOKS

1. Bimal K Bose , "Modern Power Electronics and AC Drives" , Pearson Education Asia 2002.

2. Vedam Subramanyam, "Electric Drives - Concepts and Applications", Tata McGraw Hill, 1994.

REFERENCES

1. W.Leonhard , "Control of Electrical Drives", Narosa Publishing House, 1992.

2. Murphy J.M.D and Turnbull, "Thyristor Control of AC Motors", Pergamon Press, Oxford, 1988.

PPD204 LINEAR AND NONLINEAR SYSTEM THEORY

Common to M Tech(PSE)

L	T	P	C
3	1	0	4

Prerequisite – Power Electronics

Goal

To provide an insight theory on linear and non linear control systems.

Objectives

The course should enable the students to:

1. Study the concept of state space representation of dynamic systems.
2. Study about solution of state equations of linear, nonlinear, time invariant and time varying systems and also about systems modes.
3. Know about the concepts of controllability, observability, detectability, stabilizability and reducability of time invariant and time varying systems.
4. Have an in-depth knowledge about stability of linear and nonlinear systems using Liapunov's criterion.
5. Study the concept of observable and controllable companion forms and pole placement by feedback for SISO and MIMO systems.

Outcome

At the end of the course the student should be able to:

1. Derive state space equations and draw state diagrams for physical systems
2. Solve state equations of linear, nonlinear, time invariant and time varying systems,
3. Verify if a given system is controllable, observable, detectable, stabilizable and reducable.
4. Verify if a given system is stable using Liapunov's criterion.
5. Develop observable and controllable companion forms for a given system.

UNIT I STATE VARIABLE REPRESENTATION **9**

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

UNIT II SOLUTION OF STATE EQUATION **9**

Existence and uniqueness of solutions to continuous-time state equations-Solution of Nonlinear and Linear time varying state equations-Evaluation of matrix exponential-System modes-Role of Eigenvalues and Eigenvectors.

UNIT III CONTROLLABILITY AND OBSERVABILITY **9**

Controllability and Observability-Stabilizability and Detectability-Test for Continuous time Systems-

Time varying and Time invariant case-Output Controllability-Reducibility-System Realizations.

UNIT IV STABILITY **9**

Introduction-Equilibrium Points-Stability in the sense of Liapunov-BIBO Stability-Stability of LTI Systems-Equilibrium Stability of Nonlinear continuous time autonomous systems-The direct method of Liapunov and the Linear continuous-time autonomous systems-finding Liapunov functions for nonlinear continuous time autonomous systems-Krasovskii and variable-gradiant method.

UNIT V MODAL CONTROL **9**

Introduction-Controllable and observable Companion forms-SISO and MIMO Systems-The effect of state feedback on Controllability and Observability-pole placement by state feedback for both SISO and MIMO Systems-Full order and reduced order observers.

L = 45 T = 15 Total = 60

REFERENCES:

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

PPD231 POWER ELECTRONICS AND DRIVES LABORATORY

L	T	P	C
0	0	3	2

Prerequisite
Power Electronics Lab

Goal

To provide hands on experience on the equipment for converters, inverters, choppers and simulation of closed loop control for electrical drives.

Objective

This will enable the students to enhance simulation skills on

1. Single Phase Semi-converter and full converter with R-L and R-L-E loads for continuous and discontinuous conduction modes.
2. Three phase full-converter with R-L-E load.
3. MOSFET, IGBT based Choppers and IGBT based single phase inverters
4. Simulation of closed loop control of converter fed DC motor drive,chopper fed DC drives.
5. Simulation of three phase induction motor drive and three phase synchronous motor drives.

Outcome

At the end of the course, the student should be able to :

1. Understand the working of semi converters with various firing angles and different modes of conduction
2. Understand the operation of full converter
3. Analyze inverters with different types of power switches.
4. Adequate knowledge in controlling DC Motor fed by converter
5. Adequate knowledge in simulating induction motor and synchronous motor drives

List of Experiments:

1. Single Phase Semi-converter with R-L and R-L-E loads for continuous and discontinuous conduction modes.
2. Single phase full- converter with R-L and R-L-E loads for continuous and discontinuous conduction modes.
3. Three phase full-converter with R-L-E load.
4. MOSFET, IGBT based Choppers.
5. IGBT based Single phase inverters.
6. Single phase AC voltage controller.
7. Simulation of closed loop control of converter fed DC motor drive.
8. Simulation of closed loop control of chopper fed DC motor drive.
9. Simulation of VSI fed three phase induction motor drive.
10. Simulation of three phase synchronous motor and drive.

Total : 45

List of Equipments

Sl. No.	Description	Specification	Quantity
1	Computer	Pentium 4	10
2	Pspice	Pspice 9.1 or above	10 licence user
3	MATLAB	MATLAB Ver 7.1	10 licence user
4	Power Module with three phase setup (SCR, MOSFET)	-	3
5	Firing Module (6 pulse circuit)	-	3

ELECTIVE COURSES

PCS101 ADVANCED DIGITAL SIGNAL PROCESSING

L	T	P	C
3	1	0	4

Prerequisite
Digital Signal Processing

Goal

To provide knowledge of digital signal processing methods and tools, including leading algorithms for various applications.

Objective

The course will enable the students to:

(i) Know the basics of discrete random processes

(ii) Know the basics of various Spectrum estimation methods

(iii) Know the basics of linear estimators & predictors

(iv) Know the basics of various adaptive filters along with their applications

(v) Know the fundamentals of multirate digital signal processing

Outcome

At the end of the course the students should be able to

(i) Understand the various theorems & processing that are done on discrete random processes

(ii) Understand the different parametric & non-parametric spectrum estimation methods

(iii) Understand the linear predictors & Wiener filters

(iv) Understand the adaptive filters & their various applications

(v) Understand the importance of multirate digital signal processing

UNIT I DISCRETE RANDOM SIGNAL PROCESSING 9

Discrete Random Processes- Ensemble averages, stationary processes, Autocorrelation and Auto covariance matrices. Parseval's Theorem, Wiener-Khintchine Relation- Power Spectral Density- Periodogram Spectral Factorization, Filtering random processes. Low Pass Filtering of White Noise. Parameter estimation: Bias and consistency.

UNIT II SPECTRUM ESTIMATION 9

Estimation of spectra from finite duration signals, Non-Parametric Methods-Correlation Method , Periodogram Estimator, Performance Analysis of Estimators -Unbiased, Consistent Estimators- Modified periodogram, Bartlett and Welch methods, Blackman -Tukey method. Parametric Methods - AR, MA, ARMA model based spectral estimation. Parameter Estimation -Yule-Walker equations, solutions using Durbin's algorithm

UNIT III LINEAR ESTIMATION AND PREDICTION 9

Linear prediction- Forward and backward predictions, Solutions of the Normal equations- Levinson- Durbin algorithms. Least mean squared error criterion -Wiener filter for filtering and prediction , FIR Wiener filter

and Wiener IIR filters ,Discrete Kalman filter

UNIT IV ADAPTIVE FILTERS **9**

FIR adaptive filters -adaptive filter based on steepest descent method-Widrow-Hoff LMS adaptive algorithm, Normalized LMS. Adaptive channel equalization-Adaptive echo cancellation-Adaptive noise cancellation- Adaptive recursive filters (IIR). RLS adaptive filters-Exponentially weighted RLS-sliding window RLS.

UNIT V MULTIRATE DIGITAL SIGNAL PROCESSING **9**

Mathematical description of change of sampling rate - Interpolation and Decimation , Decimation by an integer factor - Interpolation by an integer factor, Sampling rate conversion by a rational factor, Filter implementation for sampling rate conversion- direct form FIR structures, Polyphase filter structures, time-variant structures. Multistage implementation of multirate system. Application to sub band coding - Wavelet transform and filter bank implementation of wavelet expansion of signals.

L=45 T=15 Total=60

TEXT BOOK:

1. Monson H.Hayes, Statistical Digital Signal Processing and Modeling, John Wiley and Sons, Inc., Singapore, 2002.

REFERENCES:

1. John G. Proakis, Dimitris G.Manolakis, Digital Signal Processing Pearson Education, 2002.
2. John G. Proakis et.al. 'Algorithms for Statistical Signal Processing', Pearson Education, 2002.
3. Dimitris G.Manolakis et.al. ' Statistical and adaptive signal Processing', McGraw Hill, Newyork, 2000.
4. Rafael C. Gonzalez, Richard E.Woods, 'Digital Image Processing', Pearson Education, Inc., Second Edition, 2004.(For Wavelet Transform Topic)

PPD701 EMBEDDED CONTROL OF ELECTRICAL DRIVES

L	T	P	C
3	1	0	4

Prerequisite

Basic Microcontroller and Control system

Goal

To provide knowledge of control of electrical drives employing embedded controllers

Objective

The course will enable the students to:

(i) Know the basic of MC68HC11 microcontroller

(ii) Know the basic of various peripherals connected to MC68HC11

(iii) Know the basic of PIC16C7X microcontroller

(iv) Know the basic of various peripherals connected to PIC16C7X

(v) Give basic of designing a microcontroller based system

Outcome

At the end of the course the students should be able to

(i) Understand the architecture, instruction set , various peripherals of MC68HC11

(ii) Program in MC68HC11 for simple arithmetic operation and comparing

(iii) Understand the architecture, instruction set , various peripherals of PIC16C7X

(iv) Program in PIC16C7X for simple arithmetic operation

(v) Design a microcontroller based system

UNIT I MC68HC11 MICROCONTROLLER 9

Architecture memory organization - addressing modes - instruction set - programming techniques - simple programs

UNIT II PERIPHERALS OF MC68HC11 9

I/O ports - handshaking techniques - reset and interrupts - serial communication interface - serial peripheral interface - programmable timer - analog / digital interfacing - cache memory

UNIT III PIC 16C7X MICROCONTROLLER 9

Architecture - memory organization - addressing modes - instruction set - programming techniques - simple operation.

UNIT IV PERIPHERAL OF PIC16C7X MICROCONTROLLER 9

Timers - interrupts - I/O ports - I2C bus for peripheral chip access - A/D converter - UART

UNIT V SYSTEM DESIGN USING MICROCONTROLLERS 9

Interfacing LCD display - Keypad interfacing - AC load control - PID control of DC motor - stepper motor control - brush less DC motor control.

L : 45 T: 15 TOTAL : 60

TEXT BOOK

1 John B.Peatman, 'Design with PIC Microcontrollers,'Pearson Education, Asia 2004

2 Michael Khevi, 'The M68HC11 Microcontroller Applications in control,Instrumentation and communication', Prentice Hall, New Jersey, 1997.

PPD702 INTELLIGENT CONTROL
Common to M.Tech(PED)/M.Tech(PSE)

L	T	P	C
3	1	0	4

Goal

To equip the students with a knowledge of modern intelligent control techniques and their applications.

Objectives

The course should enable the students to:

1. Study the concept of approaches and architecture for intelligent control, knowledge representation and expert systems.

2. Study various concepts about artificial neural networks, types of ANN and neural network based

controller.

3. Study the concept of genetic algorithm and solution of typical problems using genetic algorithm.
4. Study the various concepts of fuzzy logic control and its applications.
5. Study the applications of expert systems, fuzzy logic control, ANN and genetic algorithm.

Outcome

At the end of the course the student should be able to:

1. Understand the concepts of intelligent control and their comparisons .
2. Understand the concepts of artificial neural network, types ofANN and to design ANN based controller.
3. Understand the concept of genetic algorithm and its applications to optimization techniques.
4. Design fuzzy logic controller.
5. Understand various intelligent control applications.

UNIT I INTRODUCTION 9

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

UNIT II ARTIFICIAL NEURAL NETWORKS 9

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

UNIT III GENETIC ALGORITHM 9

Basic concept of Genetic algorithm, algorithmic steps, adjustment of free parameters. Solution of control problems using genetic algorithm. Tabu search and ant-colony search techniques for solving optimization problems.

UNIT IV FUZZY LOGIC SYSTEM 9

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

UNIT V APPLICATIONS 9

GA application to power system optimisation problem, Case studies: Identification and control of linear and nonlinear dynamic systems .

Stability analysis of Neural-Network interconnection systems. Implementation of fuzzy logic controller. Stability analysis of fuzzy control system

REFERENCES

1. Jacek.M.Zurada, "Introduction to Artificial Neural Systems", Jaico Publishing House, 1999.
2. KOSKO,B. "Neural Networks And Fuzzy Systems", Prentice-Hall of India Pvt. Ltd.,1994.
3. KLIR G.J. & FOLGER T.A. "Fuzzy sets, uncertainty and Information", Prentice-Hall of India

Pvt. Ltd., 1993.
4. Zimmerman H.J. "Fuzzy set theory-and its Applications"-Kluwer Academic Publishers, 1994.
5. Driankov, Hellendroon, "Introduction to Fuzzy Control", Narosa Publishers

PPD703 FLEXIBLE AC TRANSMISSION SYSTEMS
Common to M Tech(ELS)& M Tech(PSE)

Goal

L	T	P	C
3	1	0	4

To provide a knowledge of application of power electronics in the efficient design and operation of power systems.

Objective

The course will enable the students:

(i) To get introduced to basic concepts of FACTS controllers.

(ii) To familiar the students with the working of series compensation.

(iii) To familiar the students with the working of Unified Power Flow Controller.

(iv) To expose the students to the designing of FACTS controllers.

(v) To familiarize the students with static VAR compensators

Outcome

After completion of the course the students are expected to be abe to:

(i) Explain the basic compensators used in power systems.

(ii) Explain how series compensation is done in power system

(iii) Explain the working of Unified Power Flow Controller.

(iv) Design variable structure of FACTS controllers for power system

(v) Explain the working of static VAR compensators and their applications in power system

UNIT I INTRODUCTION **9**

FACTS-a toolkit, basic concepts of static VAR compensator, resonance damper, thyristor controlled series capacitor, static condenser, phase angle regulator, and other controllers.

UNITII SERIES COMPENSATION SCHEMES **9**

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

UNIT III U N I F I E D POWERFLOW CONTROL **9**

Introduction, Implementation of power flow control using conventional thyristors, unified power flow concept, Implementation of unified power flow controller.

UNIT IV DESIGN OF FACTS CONTROLLERS 9

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 resistor control.

UNIT VSTATIC VAR COMPENSATION 9

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

REFERENCES

1. Narin G.Hingorani, "Flexible AC Transmission", IEEE Spectrum, April 1993,pp 40-45.
2. Narin G. Hingorani, "High Power Electronics and Flexible AC Transmission Systems IEEE High PowerEngineering Review, 1998.
3. Narin G.Hingorani, "Power Electronics in Electric Utilities : Role of Power Electronics infuture Power systems", Proc. of IEEE, Vol.76, no.4, April 1988.
4. Einar V.Larsen, Juan J. Sanchez-Gasca, Joe H.Chow, "Concepts for design of FACTS Controllers to damp power swings ", IEEE Trans On Power Systems, Vol.10, No.2, May 1995.
5. Gyugyi L., "Unified power flow control concept for flexible AC transmission", IEEE Proc-C Vol.139, No.4, July1992.

PPD705 HIGH VOLTAGE DIRECT CURRENT TRANSMISSION
Common to M.Tech (PSE)/ M.Tech(ELS)

L	T	P	C
3	1	0	4

Goal

To impart knowledge on design, simulation and analysis of HVDC converters and associated control system.

Objectives

The course should enable the students to:

1. Study the basics of dc power transmission technology and its modern trends,
2. Study the analysis of Graetz circuits for 6-pulse & 12-pulse converter characteristics,
3. Study the system control hierarchy and firing angle control ,
4. Study the characteristics and non-characteristics harmonics in HVDC system and types of Filters
5. Study about the simulation of converter station using HVDC Simulator software.

Outcome

At the end of the course the student should be able to:

1. Know the comparison of AC and DC transmission and application of HVDC transmission systems,

2. One can learn about the applications of different converter bridges,
3. Know the HVDC system control and start-stop DC link,
4. Know the different types of harmonics in HVDC system Filters to remove them,
5. One can learn about the modeling and analysis of HVDC system using HVDC simulator.

UNIT I DC POWER TRANSMISSION TECHNOLOGY 9

Introduction-comparison of AC and DC transmission application of DC transmission - description of DC transmission system planning for HVDC transmission-modern trends in DC transmission.

UNIT II ANALYSIS OF HVDC CONVERTERS 9

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

UNIT III CONVERTER AND HVDC SYSTEM CONTROL 9

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.

UNIT IV HARMONICS AND FILTERS 9

Introduction-generation of harmonics-design ofAC filters-DC filters-carrier frequency and RI noise.

UNIT V SIMULATION OF HVDC SYSTEMS 9

Introduction-system simulation: Philosophy and tools-HVDC system simulation-modeling of HVDC systems for digital dynamic simulation.

REFERENCES

1. Padiyar, K.R., "HVDC Power Transmission System", Wiley Eastern Limited, New Delhi 1990. First edition.
2. Edward Wilson Kimbark, "Direct Current Transmission", Vol. I, Wiley interscience, NewYork, London, Sydney, 1971.
3. Rakosh Das Begamudre, Extra high voltage AC transmission engineering New Age International (P) Ltd., New Delhi, 1990.
4. Arrillaga, J., High Voltage direct current transmission, Peter Pregrinus, London, 1983.

PPD706 POWER SYSTEMS FOR POWER ELECTRONICS

L T P C
3 1 0 4

OBJECTIVE:

To provide an sight into basic concept of AC transmission lines and their performance, Power flow analysis, fundamentals of automatic generation control, reactive power and voltage control and about power system stability.

UNIT I FUNDAMENTALS OF AC TRANSMISSION **9**

Review of electrical characteristics of transmission line; performance equations and natural loading, equivalent circuit of transmission line. Performance requirements of transmission lines;Voltage-current and voltage-power characteristics; power transfer and stability considerations;effect of line loss; line loadability characteristics

UNIT II STEADY STATE ANALYSIS **9**

Transfer of power between active sources. Power-flow analysis; network equations, gauss-seidel, Newton-Raphson method and Fast Decoupled methods, Comparison of the power-flow solution methods, modeling of static very systems for power-flow studies.

UNIT III ACTIVE POWER AND FREQUENCY CONTROL **9**

Fundamentals of speed-governing: Generator response to load change; load response to frequency deviation, isochronous governor; governors with speed-droop characteristics, Response rates of turbine-governing systems; Fundamentals of Automatic Generation control (AGC): AGC in isolated and interconnected systems; frequency bias tie-line control; basis for selection for bias factor-numerical example-under frequency load shedding

UNIT IV REACTIVE POWER AND VOLTAGE CONTROL **9**

Reactive power and voltage control: Production and absorption of reactive power, Methods of voltage control; shunt reactors; shunt capacitors; series capacitors and synchronous condensers, static var systems: types; fundamental frequency performance; thyristor-controlled reactor;thyristor switched capacitor; practical static var systems-steady state characteristics; application of static var systems, Principles of transmission system compensation; illustrative example.

UNIT V FUNDAMENTALS OF POWER SYSTEM STABILITY **9**

Basic concepts and definitions: rotor angle stability-synchronous machine characteristics; power-angle relationship; stability phenomenon; small-signal and transient stability, Voltage stability and voltage collapse, Classification of stability.

L = 45 T=15 Total = 60

TEXT BOOK:

1. Prabha Kundur, “Power System Stability and Control”, McGraw-Hill, Inc., 1994

REFERENCE BOOK:

1. PM Anderson and AA Fouad, “Power System Control and Stability”, Galgotia Publishers, New Delhi, 1981

PPS705 WINDENERGY CONVERSIONSYSTEMS
Common to M.E(PSE)/M.E(ELS)

L	T	P	C
3	1	0	4

Objective:

The course will enable the students to

1. To introduce the principle of wind turbines and wind energy conversion systems.
2. To learn the design and control principles of Wind turbine.
3. To understand the concepts of fixed speed and variable speed, wind energy conversion systems.
4. To analyze the grid integration issues.

Outcome

To gain the knowledge about wind energy conversion system that connected to the grid.

UNIT I INTRODUCTION **9**

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

UNIT II WIND TURBINES **9**

HAWT-VAWT-Power developed-Thrust-Efficiency-Rotor selection-Rotor design considerations-Tip speed ratio-No. of Blades-Blade profile-Power Regulation-yaw control-Pitch angle control-stall control- Schemes for maximum power extraction.

UNIT III FIXED SPEED SYSTEMS **9**

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

UNIT IV VARIABLE SPEED SYSTEMS **9**

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

UNIT V GRID CONNECTED SYSTEMS **9**

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

L=30 T=15 Total =60 hours

REFERENCES

1. L.L.Freris "Wind Energy conversion Systems", Prentice Hall, 1990
2. Ion Boldea, "Variable speed generators", Taylor & Francis group, 2006.

3. E.W .Golding "The generation of Electricity by wind power", Redwood burn Ltd., Trowbridge,1976.
4. S.Heir "Grid Integration of WECS", Wiley 1998.
5. N. Jenkins," Wind Energy Technology" John Wiley & Sons,1997
6. S.N.Bhadra, D.Kastha,S.Banerjee,"Wind Electrical Sytems",Oxford University,Press,2010.

PPS707 ENERGY AUDITING AND MANAGEMENT

Common tpM.Tech(PSE)&M.Tech(ELS)

L	T	P	C
3	1	0	4

Objective

The course will enable the students to:

1. Emphasize the energy management on various electrical equipments and metering.
2. Adopt Conservation methods in various systems.
3. Learn various technically proven ways to conserve Energy and then prioritize them based on the cost benefit analysis
4. Illustrate the concept of lighting systems and cogeneration..
5. Apply Tools for energy audit and recommend measures for energy conservation

Outcome

1. At the end of this course students will be able to work as supervisor /Energy Auditor/ Cost Analyzer in industry/Power utility/Public sector
2. Assess energy conservation potential in various systems

UNIT I INTRODUCTION **9**

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

UNIT II ENERGY COST AND LOAD MANAGEMENT **9**

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

UNIT III ENERGY MANAGEMENT FOR MOTORS, SYSTEMS, AND ELECTRICAL EQUIPMENT **9**

Energy efficient motors , factors affecting efficiency, loss distribution , constructional details , characteristics - variable speed , variable duty cycle systems, RMS hp- voltage variation-voltage unbalance- over motoring- motor energy audit. Transformer Loading/Efficiency analysis, Feeder/cable loss evaluation, case study.Reactive Power management-Capacitor Sizing-Degree of Compensation-Capacitor losses-Location-Placement-Maintenance.

UNIT IV METERING FOR ENERGY MANAGEMENT **9**

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

Metering techniques and practical examples .

UNIT V LIGHTING SYSTEMS & COGENERATION **9**

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

TOTAL : 45 PERIODS

REFERENCES

1. Reay D.A, Industrial Energy Conservation, 1st edition, Pergamon Press, 1977 .
2. IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities, IEEE, 196.
3. Amit K. Tyagi, Handbook on Energy Audits and Management, TERI, 2003.
4. Barney L. Capehart, Wayne C. Turner, and W illiam J. Kennedy, Guide to Energy Management, Fifth Edition, The Fairmont Press, Inc., 2006
5. Eastop T.D & Croft D.R, Energy Efficiency for Engineers and Technologists,. Logman Scientific & Technical, ISBN-0-582-03184, 1990.
6. Energy management by W.R. Murphy & G. Mckay Butterworth, Heinemann publications.
7. Energy efficient electric motors by John .C. Andreas, Marcel Dekker Inc Ltd-2nd edition, 1995
8. Energy management by Paul o' Callaghan, Mc-graw Hill Book company-1st edition, 1998

PPS708 DISTRIBUTED ENERGY RESOURCES

Common to M.Tech (PSE) & M.Tech (ELS)

L T P C
3 1 0 4

Objective

1. Have a working knowledge of the emerging power generation technologies such as photovoltaic arrays, wind turbines, and fuel cells.
2. Model renewable electrical energy systems for analysis and design.
3. Calculate the basic performance parameters of these systems, such as efficiency and cost.
4. Perform basic assessment and design of a renewable electrical energy system for a given application.
5. Determine the requirements for interconnecting a renewable electrical energy system to the utility electric power grid.

Outcome

At the end of the course, the student should be able to

1. Understand power generation by various technologies such as PV arrays, wind turbines and fuel cells.
2. Analysis and Design of renewable electrical energy systems
3. Analysis the performance parameters of various systems
4. Design of renewable electrical energy system

5. Understanding interconnection of renewable electrical energy to utility electric power grid

UNIT I DISTRIBUTED GENERATION INTRODUCTION 9

Distributed Generation Definition, Distributed generation advantages, challenges and needs.- Non conventional and renewable energy sources

UNIT II WIND POWER GENERATION 9

Wind Power- wind turbine and rotor types, wind speed –power curve, power coefficient, tip speed ratio, wind energy distribution, environmental impact.

UNIT III PV POWER GENERATION 9

Photovoltaic and Thermo-solar power –Solar cell technology, Photovoltaic power characteristics and Thermo-solar power generation.

UNIT IV OTHER RENEWABLES SOURCES AND TURBINES 9

Biomass Power, Fuel cells types, types of Tidal power generation schemes, mini and micro hydro power schemes, and Micro turbines for DG, bulb and tubular turbines.

UNIT V ENERGY STORAGE AND CONTROL TECHNIQUES 9

Energy Storage for use with Distributed Generation-Battery Storage, Capacitor Storage, ultra capacitors and Mechanical Storage: Flywheels, Pumped and Compressed Fluids. Control Techniques for DER integration systems- Standards and codes for interconnection- future structure of grid.

REFERENCES:

1."Distributed Power Generation, Planning & Evaluation" by H. Lee Willis & Walter G. Scott, 2000 Edition, CRC Press Taylor & Francis Group.

2. "Renewable energy power for a sustainable future" by Godfrey Boyle ,2004 Oxford University Press in association with the Open university.

3. "Fundamentals of renewable energy systems "by D.Mukherjee, S.Chakrabarti, New Age International Publishers.

4. H. Lee Willis & W. G. Scott, *Distributed Power Generation- Planning & Evaluation* , (2e), CRC Press, 2007.

5. Dr. Felix A. Farret, Dr. M. Godoy Simões , *Integration of Alternative Source of Energy* , Wiley InterScience, 2006.

6. M. H. Nehrir & C. Wang , *Modelling and Control of Fuel Cells : Distributed generaion Applications,*- IEEE Wiley- IEEE Press, 2009

7. Gilbert M. Masters , *Renewable and Efficient Electric Power Systems* , IEEE Wiley- IEEE Press, 2004.