Approved Syllabus for

Master of Technology

in

POWER & INDUSTRIAL DRIVES

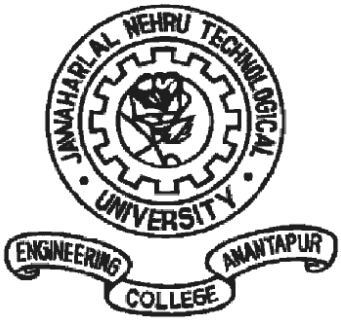
From Academic Year 2015-2016

in

BOARD OF STUDIES MEETING HELD

on

April 25th & 26th, 2015



DEPARTMENT OF ELECTRICAL ENGINEERING

COLLEGE OF ENGINEERING *(AUTONOMOUS), ANANTHAPURAMU*

JAWHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR

INFORMATION ON THE COURSE

1.0 Details about the Course.

1.1 Name of the Course (s)

Name of Degree / Diploma	Name of Specialization	Intake (Full / Part time) to be started	Year of Starting (Proposal Admission)	Duration (Total)	Name of Degree & Branch eligible for admission
M. Tech.	Power & Industrial Drives	25+7 Sponsored Full time	2009-2010	2 Yrs 4 Semesters	4 Year Degree Course B. Tech. /B.E. (EEE)

1.2 Course Structure (Semester – wise)

Name of the Subject	Hrs. / Week			
	L	T	P	C
I-SEMESTER				
1. 15D23101 Advanced Power Semiconductor Devices	4	-	-	4
2. 15D23102 Applications of Power Electronics to Power Systems	4	-	-	4
3. 15D23103 Machine Modeling & Analysis	4	-	-	4
4. 15D23104 Solid State DC Drives	4	-	-	4
6. Elective-I	4	-	-	4
7. Elective-II	4	-	-	4
8. 15D23105 Power Electronics and Drives Lab	-	-	4	2
Electives:				
15D22101 Modern Control Theory				
15D21104 Power Quality Issues & Improvement				
15D22102 Advanced Digital Signal Processing				
15D22107 Embedded Systems				
II-SEMESTER				
1. 15D23201 Advanced Power Converters	4	-	-	4
2. 15D23202 Switched Mode Power Converters	4	-	-	4
3. 15D23203 Solid State AC Drives	4	-	-	4
4. 15D22203 Intelligent Algorithms	4	-	-	4
5. Elective-I	4	-	-	4
6. Elective – II	4	-	-	4
7. 15D54201 Research Methodology (Audit Course)	2	-	-	0
8. 15D23204 Power Electronics and Drives Simulation Lab	-	-	4	2
Electives:				
15D22201 Adaptive Control				
15D22206 Process Dynamics and Control				
15D21207 Solar Energy Conversion Systems				
15D21208 Wind Energy Conversion Systems				
III SEMESTER				
1. 15D23301 Seminar - I	-	-	4	2
IV SEMESTER				
1. 15D23401 Seminar – II	-	-	4	2
III & IV SEMESTER				
1. 15D23302 Project Work	-	-	-	44

15D23101 ADVANCED POWER SEMICONDUCTOR DEVICES

UNIT-I: Introduction: 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: 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: 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(Mos Controlled Thyristor), FCT(Field Controlled Thyristor), RCT(Reverse Conducting Thyristor) .

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

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

Text books:

1. Rashid M. H., "Power Electronics Circuits, Devices and Applications", Prentice Hall India, Third Edition, New Delhi.
2. B.W. Williams 'Power Electronics: Devices, Drivers, Applications and Passive Components, Tata McGraw Hill.

Reference books:

1. M. D. Singh and K. B. Khanchandani, "Power Electronics", Tata McGraw Hill.
2. Mohan, Undeland and Robins, "Power Electronics – Concepts, applications and Design, John Wiley and Sons, Singapore.
3. Power electronics by p.s. Bimbhra, Khanna publications.
4. Advanced power electronics converters by Euzeli dos santos, Edison R. da silva.

15D23102 APPLICATIONS OF POWER ELECTRONICS TO POWER SYSTEMS

UNIT I: General System considerations and FACTS: Transmission Interconnections, Flow of Power in an AC System, Power Flow and Dynamic Stability Considerations of a Transmission Interconnection, principles of series and shunt compensation, Basic Types of FACTS Controllers, Benefits from FACTS, Application of FACTS.

UNIT II: Shunt Compensators: Objectives of Shunt Compensation, Midpoint Voltage Regulation for Line Segmentation, End of Line Voltage Support to Prevent Voltage Instability, improvement of Transient Stability, Power Oscillation Damping, Static Var Compensators, SVC and STATCOM, The Regulation Slope, Transfer Function and dynamic Performance, Transient Stability, Enhancement and Power Oscillation Damping

UNIT III: Series Compensators: Objectives of Series Compensation, concept of series capacitive compensation, voltage stability, improvement of transient stability, power oscillation damping, GTO thyristor controlled series capacitor, Thyristor controlled series capacitor, SSSC.

UNIT IV: Combined Compensators: Introduction, Unified power flow controller, basic operating principles, independent real and reactive power flow control, and control structure, basic control system for P and Q control.

UNIT V: Mitigation of Harmonics: Power quality problems, harmonics, harmonic creating loads, harmonic power flow, and mitigation of harmonics, filters, passive filters, active filters, shunt, series and hybrid filters.

Text books:

1. Narain G. Hingorani, Laszlo Gyugyi, Understanding FACTS, IEEE press
2. Roger. C. Dugan, Mark. F. McGranagham, Surya Santoso, H.Wayne Beaty, Electrical Power Systems Quality, McGraw Hill,2003

Suggested Reading:

1. Y.H.Song, A.T.Johns, Flexible A.C.Transmission System, IEE, London, 1999

15D23103 MACHINE MODELING & ANALYSIS

UNIT -I: Basic Principles for Machine Analysis: Magnetically Coupled Circuits, Machine Windings and Air-Gap MMF, Winding Inductances and Voltage Equations.
Modeling And Analysis Of DC Machines:
Elementary DC Machine, Voltage and Torque Equations, Types of DC Machines, Permanent and Shunt DC Motors, Time-Domain and State-Equations,

UNIT-II: Reference Frame Theory: Introduction to Transformations, Equations of Transformations, Change of Variables, and Transformation to an Arbitrary Reference Frame, Commonly used Reference Frames, Transformation between Reference Frames, Steady-State Phasor Relationships and Voltage Equations

UNIT-III: Modeling & Dynamic Analysis of Three Phase Induction Machines: Voltage and Torque Equations in Machine Variables, Voltage and Torque Equations in Arbitrary Reference Frame, Steady-State Analysis and its Operation.
Free Acceleration Characteristics viewed from Various Reference Frames, Dynamic Performance during Sudden Changes in Load Torque, Dynamic Performance during A Three-Phase Fault at the Machine Terminals

UNIT-IV: Modeling & Dynamic Analysis of Synchronous Machine: Voltage and Torque Equations in Machine Variables, Voltage Equations in Arbitrary and Rotor Reference Frame, Torque Equations in Substitute Variable, Steady-State Analysis and its Operation.
Dynamic Performance of Synchronous Machine, Three-Phase Fault, Comparison of Actual and Approximate Transient Torque Characteristics, Equal Area Criteria.

UNIT -V: **Modeling of Special Machines:** Modeling of Permanent Magnet Brushless DC Motor Operating principle – Mathematical modeling of PM Brushless DC motor - PMDC Motor Drive Scheme.

Text books

1. Krause, Wasynczuk, Sudhoff, **Analysis of Electric Machinery and Drive Systems**: 2nd Edition, Wiley Interscience Publications, 2002.

2. P. C. Krause, Analysis of Electric Machinery, McGraw Hill-1980

15D23104 SOLID STATE DC DRIVES

UNIT-I: DC MOTORS FUNDAMENTALS AND MECHANICAL SYSTEMS: DC motor- Types, induced emf, speed-torque relations; Speed control – Armature and field speed control; Ward Leonard control – Constant torque and constant horse power operation - Introduction to high speed drives and modern drives. Characteristics of mechanical system – dynamic equations, components of torque, types of load; Requirements of drives characteristics – multi-quadrant operation; Drive elements, types of motor duty and selection of motor rating.

UNIT-II: CONVERTER CONTROL: 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 freewheeling diode; Implementation of braking schemes; Drive employing dual converter.

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

UNIT-V: DIGITAL CONTROL OF D.C DRIVE: 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.

TEXT BOOKS

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

REFERENCES

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

15D23105 POWER ELECTRONICS AND DRIVES LAB

List of Experiments

1. Study of DSP board and Generation of 3-phase Pulse Width Modulated (PWM) Sequence
2. Generation of SINE-Triangular PWM for single/ three-phase inverter system
3. Generation of Space-vector modulation PWM for single/ three-phase inverter system
4. Speed control of inverter fed induction motor using sine-triangular PWM method.
5. Speed control of inverter fed induction motor using space-vector PWM method.
6. Speed control of chopper fed separately excited dc motor (four quadrant operation).
7. Closed loop speed control of BLDC motor/ PMSM/ SRM

XILINX Based

1. (a) Demonstration about FPGA processor, its importance in the advanced controller era :: Understanding Spartan-3E diligent board.

(b) Demonstration about Xilinx-9i based Electronic Distribution and Automation (EDA) Software, HDL languages (Verilog & VHDL) and Synthesis.

Note: At least two problems may be implemented from the following

2. Design the following Simple logic circuits in Xilinx-9i EDA Software using Verilog / VHDL language and obtain its Synthesis.

   (i) AND, OR logic gates and (ii) Half Adder.

3. Design of Top-Bottom level (Instantiation) modular circuits of the following in Xilinx-9i EDA Software using Verilog/VHDL language and obtain its Synthesis.

   (i) Instantiate AND-AND logic to OR gate.
   (ii) Instantiate two Half Adders to obtain Full Adder.

4. Generate single pulse PWM output by writing counter program in Xilinx EDA software, obtain its Synthesis and timing simulation.
5. Generate multi pulse PWM output by writing counter program in Xilinx EDA software, obtain its Synthesis and timing simulation.
6. Instantiate DCM)/UART write a user constraint file to assign pin packages and implement Spartan-3E diligent board observe LED outputs
7. Design digital logic circuit to obtain stepper motor control and implement in Spartan-3E diligent board.

15D22101 MODERN CONTROL THEORY

Unit I

Fields, Vectors, and vector spaces; State space representation, state equations for dynamic systems, solution of state equations; State transition matrix – Properties of state transition matrix; evaluation. Fadeeva algorithm for conversion from state space to transfer function, Linearization of non-linear models

Unit II

Non uniqueness of state model, Similarity transformation, Invariance of system properties. Controllability – necessary and sufficient condition - Pole assignment using State feedback – Ackerman's formula for feedback gain determination; Observability. Duality. Effect of state feedback on controllability and observability. Controllable subspace – decomposition of state into controllable and uncontrollable components.

Unit III

Design of full order observer – Bass Gura algorithm. The separation principle - Combined observer – controller compensator. Design of reduced order observer. Unobservable subspace – decomposition of state into observable and unobservable components – Canonical decomposition theorem.

Unit IV

Reducibility – realization of transfer function matrices. Model decomposition and decoupling by state feedback. Design of robust control system for asymptotic tracking and disturbance rejection using State variable equations. Transfer function interpretations – transfer function form of observer and state estimate feedback. State space interpretation of internal model principle.

Unit V

Discrete time linear state regulator – Algorithm for the solution, Use of observer in implementing the control law. Continuous time linear state regulator – Matrix Riccati equation. Time invariant linear state regulator – the reduced matrix Riccati equation - An iterative method to solve the reduced matrix Riccati equation. Suboptimal linear regulator.

Text Books:

1. Modern Control Engineering, Katsuhiko Ogata, 5th Edition, Prentice Hall India, 1997
2. Modern Control System Theory, M. Gopal, Revised 2nd Edition, New Age International Publishers, 2005.

References:

1. Linear Systems, Thomas Kailath, Perntice Hall, 1980.
2. Control System Design, Graham C. Goodwin, StefanF. Graebe and Mario E. Salgado, Pearson Education, 2000.
3. Linear System Theory and Design, Chi-Tsong Chen, OXFORD University Press.
4. Richard C. Dorf and Robert H. Bishop, Modern Control Systems, 11th Edition, Pearson Edu India, 2009.

15D21104 POWER QUALITY ISSUES & IMPROVEMENT

UNIT I: INTRODUCTION TO POWER QUALITY

Definition of Power Quality - Power Quality Progression - Power Quality Terminology - Power Quality Issues - Susceptibility Criteria - Responsibilities of Power Suppliers and Users - Power Quality Standards.

UNIT II: POWER FREQUENCY DISTURBANCE & TRANSIENTS

Introduction to Power Frequency Disturbance - Common Power Frequency Disturbances - Cures for Low Frequency Disturbances - Voltage Tolerance Criteria - ITIC Graph - Introduction to Transients - Transient System Model - Examples of Transient Models and Their Response - Power System Transient Modeling - Types and Causes of Transients - Examples of Transient Waveforms.

UNIT III: HARMONICS & ELECTROMAGNETIC INTERFERENCE (EMI)

Definition of Harmonics - Harmonic Number (h) - Odd and Even Order Harmonics - Harmonic Phase Rotation and Phase Angle - Voltage and Current Harmonics - Individual and Total Harmonic Distortion - Harmonic Signatures - Effect of Harmonics On Power System Devices - Guidelines For Harmonic Voltage and Current Limitation - Harmonic Current Mitigation - Introduction to EMI - Frequency Classification - Electrical Fields - Magnetic Fields - EMI Terminology - Power Frequency Fields - High Frequency Interference - EMI Susceptibility - EMI Mitigation - Cable Shielding - Health Concerns of EMI.

UNIT IV: GROUNDING AND BONDING

Introduction to Grounding and Bonding - Shock and Fire Hazards - NEC Grounding Requirements - Essentials of a Grounded System - Ground Electrodes - Earth Resistance Tests - Earth Ground Grid Systems - Power Ground System - Signal Reference Ground (SRG) - SRG Methods - Single and Multipoint Grounding - Ground Loops - Electrochemical Reaction - Examples of Grounding Anomalies.

UNIT V: MEASURING AND SOLVING POWER QUALITY PROBLEMS

Introduction to Power Quality Measurements - Power Quality Measurement Devices - Power Quality Measurements - Test Locations - Test Duration - Instrument Setup - Instrument Guidelines

TEXT BOOKS:

1. Power quality by C. Sankaran, CRC Press
2. Electrical Power Systems Quality, Roger C. Dugan, Mark F. McGranaghan, Surya Santoso, H.Wayne Beaty, 2nd Edition, TMH Education Pvt. Ptd.

REFERENCE BOOKS:

1. Understanding Power quality problems by Math H. J. Bollen IEEE Press
2. Power quality enhancement using custom power devices by Arindam Ghosh,Gerard Ledwich,Kluwer academic publishers

15D22102 ADVANCED DIGITAL SIGNAL PROCESSING

UNIT-I:
Short introduction, Analog to digital and Digital to Analog conversion, sampled and Hold circuit, Continuous time Fourier Transforms. Discrete-time signals and systems, Discrete-time Fourier transform- its properties and applications, Fast Fourier Transform (in time-domain and Frequency domain) , IDFT and its properties.

UNIT-II: z- Transforms
Definition and properties, Rational z-transforms, Region of convergence of a rational z- Transform, The inverse z- Transform, z-Transform properties, Computation of the convolution sum of finite-length sequences, The transfer function.

Digital Filter Structures: Block Diagram representation, Equivalent structures, Basic FIR Digital Filter structures, Basic IIR Digital Filter structures, Realization of Basic structures using MATLAB, All pass filters, Computational complexity of Digital filter structures.

UNIT III: **IIR Digital Filter Design:**
Preliminary considerations, Bilinear transformation method of IIR Filter design, Design of low pass IIR Digital filters, Design of High pass, Band pass and band stop IIR digital filters, Spectral Transformations of IIR filter, IIR digital filter design using MATLAB, Computer aided design of IIR digital filters.

UNIT IV:FIR Digital Filter Design:
Preliminary considerations, FIR filter design based on windowed Fourier series, Computer aided design of Equiripple Linear phase FIR filters, Design of Minimum phase FIR filters, FIR digital filter design using MATLAB, Design of computationally efficient FIR digital filters.

UNIT V: Analysis of Finite word length effects:
The quantization process and errors, quantization of Fixed point numbers, Quantization of floating point numbers, Analysis of coefficient quantization effects, Analysis of arithmetic round off errors, Low sensitivity digital filters, Reduction of product round off errors using error feedback, Round off errors in FFT algorithms. The basic sample rate alteration devices, Multi rate structures for sampling rate conversion, Multistage design of decimator and interpolator, The Polyphase decomposition, Arbitrary-rate sampling rate converter, Nyquist Filters and some applications of digital signal processing.

Text Books:
1. S.K. Mitra**, Digital Signal Processing**-, Tata McGraw-Hill, Third Edition, 2006.
2. B.P. Lathi, **Principle of Signal Processing and Linear Systems**-, Oxford International Student Version, 2009
3. M. Mondal and A Asif, **Continuous and Discrete Time Signals and Systems**, Cambridge, 2007

References:
1. Li Tan, **Digital Signal Processing- Fundamentals and Applications**-, Indian reprint, Elsevier, 2008.
2. Alan V. Oppenheim, Ronald W. Schafer, and John R.Buck, **Discrete- Time Signal Processing**-, Pearson Edu, 2008.

15D22107 EMBEDDED SYSTEMS

UNIT- I Embedded Systems: **Processor & Memory Organization**
Embedded System, types of Embedded System, Requirements of Embedded System, Issues in Embedded software development, Applications, Structural units in a processor, Processor selection, Memory devices, Memory selection, Memory Allocation & Map; Interfacing

UNIT-II: **Devices, Device Drivers & Buses for Device Networks**
I/O devices, Timer & Counter devices, Serial Communication, Communication between devices using different buses, Device drives, Parallel and serial port device drives in a system, Interrupt servicing mechanism, context and periods for context switching, Deadline and Interrupt Latency.

UNIT-III: **Real Time Operating Systems**
Operating System Services, I/O Subsystems, Network Operating Systems, Real-Time and Embedded System Operating Systems, Interrupt Routines and Handling of Interrupt Source Call in RTOS, RTOS task scheduling Models, Interrupt Latency and Response Times of the Tasks, Performance Metric in Scheduling Models for different Tasks, IEEE standard POSIX 1003.1b Functions for standardization of RTOS and Inter_Task Communication Functions, List of basic actions in a Preemptive Scheduler and Expected Times taken at a processor, Fifteen-point Strategy for Synchronization between the Processes, ISRs, OS Functions and Tasks for Resource Management, OS Security Issues, Mobile OS.

UNIT-IV: Hardware-Software Co-Design in an Embedded System
Embedded System Project Management, Embedded system design and co-design issues in system development process, design cycle in development phase for Embedded System, Uses of its Emulator and In-Circuit Emulator (ICE), Use of Software tools for development of an Embedded System, Use of scopes and Logic Analyzers for system Hardware tests, Issues in Embedded system design

UNIT-V: Applications
Embedded System Design for: An Adaptive Cruise Control System in a car, Smart Card, Digital Clock, Battery-operated Smartcard Reader, Automated Meter Reading (AMR) System, Digital Camera

TEXT BOOKS:

1. Raj Kamal, “Embedded Systems : Architecture, Programming and Design”, Tata McGraw Hill, 2005
2. Shibu. K. V, “Introduction to Embedded Systems”, Tata McGraw Hill, 2009

15D23201 ADVANCED POWER CONVERTERS

UNIT-I: PWM Inverters: Principle of Operation – Performance Parameters – Single Phase Bridge Inverter – Output Voltage and Current With R, R-L & R-L-C Loads – Voltage Control of Single Phase Inverters – Advanced Modulation Techniques for Improved Performance –Numerical Problems.

Three Phase Inverters –180 Degree Condition –120 Degree Conduction – Analysis – Output Voltage and Current With R, R-L & R-L-C Loads – Voltage Control of Three Phase Inverters – Comparison of PWM Techniques – Harmonic Reductions – Current Source Inverter – Variable DC Link Inverter – Buck and Boost Inverter – Inverter Circuit Design – Applications – Numerical Problems.

UNIT-II: Resonant Pulse Inverters: Series Resonant Inverters – Analysis with Unidirectional Switches & Bidirectional Switches – Evaluation of Currents and Voltages – Frequency Response of Series Resonant Inverters – Series Loaded Inverter –Parallel Loaded Inverter –Series and Parallel Loaded Inverters – Parallel Resonant Inverters – Voltage Control of Resonant Inverters – Class E Resonant Inverter & Class E Resonant Rectifier – Numerical Problems.

Resonant Converters – Zero Current Switching Resonant Converters – L Type– M Type – Zero Voltage Switching Resonant Converters – Comparison Between ZCS And ZVS – Resonant Converters – Two Quadrant ZVS Resonant Converters – Resonant DC-Link Inverters – Numerical Problems.

UNIT-III: Multilevel Inverters

Multilevel Concept – Types of Multilevel Inverters – Diode Clamped Multilevel Inverter – Improved Diode Clamped Inverter – Flying Capacitors Multilevel Inverter – Cascaded Multilevel Inverter– Principle Of Operation – Main Features– Applications – Reactive Power Compensation, Back to Back Intertie System, Adjustable Drives– Switching Device Currents – DC Link Capacitor Voltage Balancing – Features of Multilevel Inverters –Comparisons of Multilevel Converters – Numerical Problems.

UNIT-IV: DC Power Supplies :DC Power Supplies – Types – Switched Mode DC Power Supplies – Fly Back Converter –Forward Converter – Push-Pull Converter – Half Bridge Converter – Full Bridge Converter –Resonant DC Power Supplies – Bidirectional Power Supplies – Applications – Numerical Problems.

UNIT-V: AC Power Supplies: AC Power Supplies – Types – Switched Mode Ac Power Supplies – Resonant AC Power Supplies – Bidirectional Ac Power Supplies – Multistage Conversions – Control Circuits – Power Line Disturbances – Power Conditioners – Uninterruptible Power Supplies – Applications – Numerical Problems.

TEXT BOOKS:

1. Power Electronics – Mohammed H. Rashid – Pearson Education – Third Edition.
2. Power Electronics – Ned Mohan, Tore M. Undeland and William P. Robbins – John Wiley and Sons – Second Edition

15D23202 SWITCHED MODE POWER CONVERTERS

UNIT –I DC-DC Converters: Buck Converter, Boost Converter, Buck-boost converter, Cuk converter – Steady-State Analysis, Duty Ratio, Volt-Sec Balance and Voltage Gain, Average Voltage and Current Expressions, Ripple Current and Voltage Expressions, Finding Performance Parameters, Numerical problems, Comparison of Converters, Multi Output Boost Converters, Diode Rectifier fed Boost Converter, Chopper Circuit Design.

UNIT – II Dynamic Analysis of Dc-Dc Converters: Formulation of averaged Circuit Models of Buck, Boost and buck-boost Converters, Small Signal Analysis and Linearization– Need for Small Signal Models, Obtaining Models, Generalizing the Process.
Introduction to Control Design and Control Design based on Linearization - Transfer Functions, Compensation and Filtering, Numerical problems. Voltage Mode, Current Mode and Hysteresis Controls for DC – DC Converters.

UNIT – III Single-Switch Isolated Converters: Requirement for Isolation in the Switch-Mode Converters, Transformer Connection, Forward and Fly Back Converters, Power Circuit and Steady-State Analysis – Finding Performance Parameters - Numerical Problems
Push-Pull Converters: Power Circuit and Steady-State Analysis, Utilization of Magnetic Circuits in Single Switch and Push-Pull Topologies - Finding Performance Parameters - Numerical Problems.

UNIT – IV Isolated Bridge Converters: Half Bridge and Full-Bridge Converters, Power Circuit and Steady-State Analysis, Utilization of Magnetic Circuits and Comparison with Previous Topologies, Numerical Problems.
Configurations of Resonant DC Power Supplies – Bidirectional Power Supplies – Switch Mode AC Power Supplies – Resonant Ac Power Supplies – Bidirectional AC Power Supplies - Finding Performance Parameters – Numerical Problems.
UNIT – V Resonant Converters & Quasi-Resonant Converters:
Classification of Resonant Converters-Basic Resonant Circuits - Series Resonant Circuit - Parallel Resonant Circuits - Resonant Switches, Numerical Problems.
Concept of Zero Voltage Switching, Concept of Zero Current Switching – Principle Of Operation, Analysis of M-Type And L-Type Buck or Boost Converters, Numerical Problems.

TEXT BOOKS:
1. Robert Erickson and Dragon Maksivimovic, **Fundamentals of Power Electronics**, Springer Publications.
2. Issa Batarseh**, Fundamentals of Power Electronics,** John Wiley Publications, 2009.
3. M. H. Rashid, **Power Electronics Circuits, Devices and Applications**, Prentice Hall ,2003

REFERENCE BOOKS:
1. Philip T.Krein **Elements of Power Electronics** - Oxford University Press, 1997.
2. L. Umanand **Power Electronics,** Tata Mc-Graw Hill, 2004.
3. Robert Erickson and Dragon Maksivimovic, **Fundamentals of Power Electronics**, Springer Publications.

15D23203 SOLID STATE AC DRIVES

UNIT-I: Induction Motor- An Overview

Review of Steady-State Operation of Induction Motor, Equivalent Circuit Analysis, Torque-Speed Characteristics.

Phase Controlled Induction Motor Drive

Stator Voltage Control of Induction Motor, Phase-Controlled Converter Fed Induction Motor, Power Circuit and Gating, Reversible Phase-Controlled Induction Motor Drive, Torque-Speed Characteristics.

UNIT-II: Voltage Source Inverter Fed Induction Motor Drive

Stator Voltage and Frequency Control of Induction Motor, Torque-Speed Characteristic Static Frequency Changers, PWM Inverter Fed Induction Motor Drive, Variable-Voltage Variable-Frequency Operation of Induction Motor, Constant E/f And V/f Control Schemes, Slip Regulation.

Current Source Inverter Fed Induction Motor Drive

Stator Current and Frequency Control of Induction Motor, Auto Sequentially Commutated Inverter (ASCI), Power Circuit, Commutation, Phase Sequence Reversal, Regeneration, Steady-State Performance.

UNIT-III: Rotor Side Control of Slip-Ring Induction Motor

Slip-Power Recovery Schemes, Steady-State Analysis- Range of Slip, Equivalent Circuit, Performance Characteristics; Rating of Converters.

Vector Control of Induction Motor

Principles of Vector Control, Direct Vector Control, Derivation of Indirect Vector Control, Implementation – Block Diagram, Estimation of Flux, Flux Weakening Operation.

UNIT-IV: Control of Synchronous Motor Drives

Synchronous Motor and Its Characteristics- Control Strategies-Constant Torque Angle Control-Power Factor Control, Constant Flux Control, Flux Weakening Operation, Load Commutated Inverter Fed Synchronous Motor Drive, Motoring and Regeneration, Phasor Diagrams.

Unit-V: PMSM and BLDC Drives

Characteristics of Permanent Magnet, Synchronous Machines With Permanent Magnet, Vector Control of PMSM- Motor Model and Control Scheme, Constant Torque Angle Control, Constant Mutual Flux Linkages, Unity PF Control. Modeling of PM Brushless Dc Motor, Drive Scheme, Commutation Torque Ripple, Phase Advancing.

TEXT BOOK:

1.R. Krishnan, **Electric Motor Drives Modeling, Analysis & control**, Pearson Education, 2001.

REFERENCE BOOKS:

1. B. K. Bose **Modern Power Electronics and AC Drives**, Pearson Publications-2001.
2. MD Murphy & FG Turn Bull, Pergaman press, **Power Electronics control of AC motors** 1st edition-1998.
3. G.K. Dubey **Fundamentals of Electrical Drives** Narosa Publications -1995.

15D22203 INTELLIGENT ALGORITHMS

UNIT I:

Introduction and motivation. Approaches to intelligent control. Architecture for intelligent control. Symbolic reasoning system, rule - based systems, the AI approach. Knowledge representation. Expert systems. Data Pre - Processing: Scaling, Fourier transformation, principal - component analysis and wavelet transformations.

UNIT II

Concept of Artificial Neural Networks and its basic mathematical model, McCulloch - Pitts neuron model, simple perceptron, Adaline and Madaline, Feed - forward Multilayer Perceptron. Learning and Training the neural network. Networks: Hopfield network, Self - organizing network and Recurrent network. Neural Network based controller, Case studies: Identification and control of linear and nonlinear dynamic systems using Matlab / Neural Network toolbox.

UNIT III

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

UNIT IV

Introduction to crisp sets and fuzzy sets, basic fuzzy set operation and approximate reasoning. Introduction to Fuzzy logic modeling and control of a system. Fuzzification, inference and defuzzification. Fuzzy knowledge and rule bases.

UNIT V

Fuzzy modeling and control schemes for nonlinear systems. Self - organizing fuzzy logic control. Implementation of fuzzy logic controller using Matlab fuzzy - logic toolbox. Stability analysis of fuzzy control systems. Intelligent Control for SISO/MIMO Nonlinear Systems. Model Based Multivariable Fuzzy Controller.

TEXT BOOKS

1. Simon Haykins, Neural Networks: A comprehensive Foundation, Pearson Edition, 2003.
2. T.J.Ross, Fuzzy logic with Fuzzy Applications, Mc Graw Hill Inc, 1997.
3. David E Goldberg, Genetic Algorithms.

REFERENCES

1. M.T.Hagan, H. B. Demuth and M. Beale, Neural Network Design, Indian reprint, 2008.
2. Fredric M.Ham and Ivica Kostanic, Principles of Neurocomputing for science and Engineering, McGraw Hill, 2001.
3. N.K. Bose and P.Liang, Neural Network Fundamentals with Graphs, Algorithms and Applications, Mc - Graw Hill, Inc. 1996.
4. Yung C. Shin and Chengying Xu, Intelligent System - Modeling, Optimization and Control, CRC Press, 2009.
5. N.K.Sinha and Madan M Gupta, Soft computing & Intelligent Systems - Theory & Applications, Indian Edition, Elsevier, 2007.
6. John Yen and Reza Langari, Fuzzy logic Intelligence, Control, and Information, Pearson Education, Indian Edition, 2003.
7. Witold Pedrycz, Fuzzy Control and Fuzzy Systms, Overseas Press, Indian Edition, 2008.

15D54201 RESEARCH METHODOLOGY

(Audit Course)

UNIT I

Meaning of Research – Objectives of Research – Types of Research – Research Approaches – Guidelines for Selecting and Defining a Research Problem – research Design – Concepts related to Research Design – Basic Principles of Experimental Design.

UNIT II

Sampling Design – steps in Sampling Design –Characteristics of a Good Sample Design – Random Sampling Design.

Measurement and Scaling Techniques-Errors in Measurement – Tests of Sound Measurement – Scaling and Scale Construction Techniques – Time Series Analysis – Interpolation and Extrapolation.

Data Collection Methods – Primary Data – Secondary data – Questionnaire Survey and Interviews.

UNIT III

Correlation and Regression Analysis – Method of Least Squares – Regression vs Correlation – Correlation vs Determination – Types of Correlations and Their Applications

UNIT IV

Statistical Inference: Tests of Hypothesis – Parametric vs Non-parametric Tests – Hypothesis Testing Procedure – Sampling Theory – Sampling Distribution – Chi-square Test – Analysis of variance and Co-variance – Multi-variate Analysis.

UNIT V

Report Writing and Professional Ethics: Interpretation of Data – Report Writing – Layout of a Research Paper – Techniques of Interpretation- Making Scientific Presentations in Conferences and Seminars – Professional Ethics in Research.

Text books:

1. **Research Methodology:Methods and Techniques – C.R.Kothari, 2nd Edition,New Age International Publishers.**
2. **Research Methodology: A Step by Step Guide for Beginners- Ranjit Kumar, Sage Publications (Available as pdf on internet)**
3. **Research Methodology and Statistical Tools – P.Narayana Reddy and G.V.R.K.Acharyulu, 1st Edition,Excel Books,New Delhi.**

REFERENCES:

1. **Scientists must Write - Robert Barrass (Available as pdf on internet)**
2. **Crafting Your Research Future –Charles X. Ling and Quiang Yang (Available as pdf on internet)**

15D23204 POWER ELECTRONICS AND DRIVES SIMULATION LAB

List of Experiments

1. **Simulation of 1-phase/ 3-phase IGBT based bridge inverter circuits with R, R-L loads.**
2. **Simulation of 3-phase bridge inverter.**
3. **Simulation of 1-phase/3-phase thyristorized converters (semi, full converter)**
4. **Simulation of 3-phase converters.**
5. **Simulation of speed control of separately excited DC motor.**
6. **Simulation of Closed loop speed control of BLDC motor.**
7. **Simulation of DC-DC converters (Buck, boost and Buck-boost converters).**
8. **Simulation of two-level and three-level inverter with sinusoidal PWM.**
9. **Simulation of VSI fed Induction motor (square wave and PWM inverters).**
10. **Simulation of induction motor with open loop constant V/F control.**
11. **Simulation of induction motor with indirect vector control.**
12. **Simulation of PMSM.**

(Simulation software tools: Matlab/Simulink/PSPICE/PSIM)

15D22201 ADAPTIVE CONTROL

UNIT – I

Introduction, Block Diagram of an Adaptive System, Effects of Process Variations on System Performance, Types of Adaptive Schemes, Formulation of The Adaptive Control Problem, Abuses of Adaptive Control, Least Squares Method and Regression Models for Parameter Estimation – Theorems, Estimating Parameters in Models of Dynamic Systems, The Finite Impulse Response Model, The Transfer Function Model, and The Stochastic Model.

UNIT – II

Block Diagram of Deterministic Self Tuning Regulator (STR), Pole Placement Design – Process Model, Model Following, Causality Conditions. Indirect STRs – Estimation, Continuous - Time STRs, Direct STRs – Minimum Phase Systems, Adaptive Control Algorithm, Feed Forward Control, Non Minimum Phase Systems – Adaptive Control Algorithm, Algorithm For Hybrid STR.

UNIT – III

Design of Minimum Variance and Moving - Average Controllers, Stochastic STR – Indirect STR, Algorithm for Basic STR, Theorems on Asymptotic Properties. Unification of Direct STRs, Generalized Direct Self Tuning Algorithm, Self Tuning Feed Forward Control. Linear Quadratic STR – Theorems on LQG Control, Algorithms for Indirect LQG – STRs Based on Spectral Factorization and Riccati Equation.

UNIT –IV

Model Reference Adaptive System (MRAS), The MIT Rule, Block Diagram of an MRAS for adjustment of Feed Forward Gain based on MIT Rule. Adaptation Gain – Methods for determination. Design of MRAS using Lyapunov Theory – Block Diagram of an MRAS based on Lyapunov Theory for a First Order System. Proof of The Kalman – Yakubovich Lemma, Adjustment Rules for Adaptive Systems, Relation between MRAS and STR.

UNIT – V

Gain Scheduling – Principle, Block Diagram, Design of Gain Scheduling Controllers, Nonlinear Transformations, Block Schematic of a Controller based on Nonlinear Transformations. Application of Gain Scheduling for Ship Steering, Flight Control. Self Oscillating Adaptive System (SOAS) – Principle, Block Diagram, Properties of The Basic SOAS, Procedure for Design of SOAS. Industrial Adaptive Controllers and applications.

Text books

1. K.J.Astrom and Bjorn Wittenmark, Adaptive control, Pearson Edu., 2nd Edn.
2. Sankar Sastry, Adaptive control.

References

1. V.V.Chalam, Adaptive Control System - Techniques & Applications, Marcel Dekker Inc.
2. Miskhin and Braun, Adaptive control systems, MC Graw Hill
3. Karl Johan Åström, Graham Clifford Goodwin, P. R. Kumar, Adaptive Control, Filtering and Signal Processing
4. G.C. Goodwin, Adaptive control.
5. Narendra and Anna Swamy, Stable Adaptive Systems.

15D22206 PROCESS DYNAMICS AND CONTROL

UNIT I:
Introduction to Process Control, Representative Process Control Problems, Illustrative Example-A Blending process, Classification of Control Strategies, Hierarchy of Process Control activities, Dynamic versus Steady - state Models, The rationale of Dynamic Process models, General Modeling Principles, Dynamic model of CSTR, Degrees of freedom analysis, Linearization of Non-linear models. Processes with time delays, Approximation of Higher - Order transfer functions, Interacting and Non interacting Processes, Multiple - Input, Multiple - Output (MIMO) Processes.

UNIT II:
Basic Control modes, Features of PID Controllers, Typical process responses with Feedback control, Digital versions of PID Controllers, Transducers and Transmitters, Final Control elements, Accuracy in Instrumentation, Guidelines for selection of Controlled, Manipulated and Measured variables, Process safety and Process Control, Block diagram representation of Blending process composition control system, General stability criterion, Routh Stability criterion for time delay systems, Direct substitution method.

UNIT III:
Performance Criteria for Closed - Loop Systems, Model - based design methods - Direct Synthesis Method, Internal Model Control, Controller tuning relations, Controllers with two degrees of freedom, Online controller tuning, trial and error tuning, Continuous Cycling Method, Relay auto tuning, Process Reaction Curve Method, Guidelines for Common Control Loops, troubleshooting Control Loops.

UNIT IV:
Introduction to Feed forward Control, Ratio Control, Feed forward Controller Design based on Steady - State Models, Controller Design based on Dynamic Models, Tuning Feed forward Controllers, Configurations for Feed forward - Feedback Control, Cascade control, Design considerations for cascade control, Time delay compensation, Block diagram of the Smith predictor, Inferential control, Selective control/Override systems.

UNIT V:
Multi loop and multivariable control: Process Interactions and Control Loop Interactions, Pairing of Controlled and Manipulated Variables, Bristols RGA method, Calculation of the RGA, Methods for obtaining the steady state gain matrix, Measure of Process Interactions and Pairing recommendations, Dynamic considerations, Extensions of the RGA analysis, Singular value analysis, Selection of manipulated variables and Controlled variables, Tuning of multi loop PID Control systems, Decoupling and multi variable control strategies, Strategies for Reducing Control Loop Interactions.

TEXT BOOKS:

1. Dale E. Seborg, University of California, Santa Barbara, Thomas F. Edgar, University of Texas at Austin, Duncan A. Mellichamp, University of California, Santa Barbara, Process Dynamics and Control, John Wiley & Sons, 1989.
2. Dale E. Seborg, University of California, Santa Barbara, Thomas F. Edgar, University of Texas at Austin, Duncan A. Mellichamp, University of California, Santa Barbara, Process Dynamics and Control, John Wiley & Sons, 2nd Edition, 2004.

REFERENCES:

1. Brian Roffel, Ben Betlem, Process Dynamics and Control Modeling for Control and Prediction, John Wiley & Sons Ltd., 2007.

15D21207 SOLAR ENERGY CONVERSION SYSTEMS

UNIT-I: SOLAR CELL FUNDAMENTALS

Place of PV in world energy scenario – need for sustainable energy sources – current status of Renewable energy sources – place of photovoltaic in Energy supply – solar radiation – the sun and earth movement – angle of sunrays on solar collectors – sun tracking – estimating solar radiation empirically – measurement of solar radiation - Fundamentals of semiconductors – charge carriers and their motion in semiconductor – P-N Junction Diode – an introduction to solar cells.

UNIT-II: DESIGN OF SOLAR CELLS

Upper limits of cell parameters – short circuit current, open circuit voltage, fill factor, efficiency – losses in solar cells – model of a solar cell, effect of series and shunt resistance on efficiency , effect of solar radiation on efficiency – solar cell design – design for high I_{SC} – Design for high V_{OC} – design for high FF – Analytical techniques.

UNIT-III: SOLAR PHOTOVOLTAIC MODULES

Solar PV Modules from solar cells – series and parallel connection of cells – mismatch in module – mismatch in series connection – hot spots in the module , bypass diode – mismatching in parallel diode – design and structure of PV modules – number of solar cells in a module, wattage of modules, fabrication of PV module – PV module power output.

UNIT-V: BALANCE OF SOLAR PV SYSTEMS

Basics of Electromechanical cell – factors affecting performance – batteries for PV systems – DC to DC converters – charge controllers – DC to AC converters(Inverters) – Maximum Power Point tracking (MPPT) – Algorithms for MPPT.

UNIT V: PV SYSTEM DESIGN AND GRID CONNECTED APPLICATIONS

Introduction to solar PV systems – standalone PV system configuration – design methodology of PV systems – design of PV powered DC fan without battery, standalone system with DC load using MPPT, design of PV powered DC pump, design of standalone system with battery and AC/DC load – wire sizing in PV system – precise sizing of PV systems –off- grid systems – layout – design – grid-Tied systems – mini-grid systems - Hybrid PV systems – grid connected PV systems.

TEXT BOOKS:

1. “Solar Photovoltaics Fundamentals, Technologies and Applications” by Chetan singh solanki, PHI publications-2011.

REFERENCES:

1. Solar Energy Fundamentals and applications by H.P. Garg, J. Prakash “Tata McGraw- Hill publishers Ist edition”
2. S.Rao & B.B.Parulekar, “Energy Technology”, 4th edition, Khanna publishers, 2005.

15D21208 WIND ENERGY CONVERSION SYSTEMS

UNIT-I: FUNDAMENTALS OF WIND TURBINES

Historical background - basics of mechanical to electrical energy conversion in wind energy - types of wind energy conversion devices – definition - solidity, tip speed ratio, power coefficient, wind turbine ratings and specifications - aerodynamics of wind rotors - design of the wind turbine rotor

UNIT-II: WIND TURBINE CONTROL SYSTEMS & SITE ANALYSIS

Power speed characteristics - torque speed characteristics - Pitch angle control – stall control – power electronic control – Yaw control – Control strategy – wind speed measurements – wind speed statistics – site and turbine selection.

UNIT-III: BASICS OF INDUCTION AND SYNCHRONOUS MACHINES

The Induction Machine – constructional features - equivalent circuit model - performance characteristics - saturation characteristics – dynamic d-q model – the wound – field synchronous machine – the permanent magnet synchronous machine – power flow between two synchronous sources – induction generator versus synchronous generator – stand alone & grid integration techniques for synchronous machines – layout - .

UNIT-IV: GRID CONNECTED AND SELF-EXCITED INDUCTION GENERATOR OPEARTION

Constant – voltage, constant – frequency- single output system –double output system with current converter & voltage source inverter – equivalent circuits – reactive power and harmonics – reactive power compensation – variable – voltage, variable – frequency generation – the self- excitation process – circuit model for the self – excited induction generator – analysis of steady state operation – the steady state characteristics – the excitation requirement – effect of a wind generator on the network .

UNIT-V: WIND GENERATION WITH VARIABLE-SPEED TURBINES AND APPLICATION

Classification of schemes – operating area – induction generators – doubly fed induction generator – wound field synchronous generator – the permanent magnet generator – Merits and limitations of wind energy conversion systems – application in hybrid energy systems – diesel generator and photovoltaic systems – wind photovoltaic systems.

TEXT BOOKS:

1. S.N.Bhadra,D.Kastha, S.Banerjee, " wind electrical systems" Oxford University Press-2005.

REFERENCES:

1. S.Rao & B.B.Parulekar, "Energy Technology", 4th edition, Khanna publishers, 2005.
2. "Renewable Energy sources & Conversion Technology" by N.K.Bansal, Manfred Kleemann, Michael Meliss. Tata Mcgraw Hill Publishers.