GMRIT

Curriculum
2021

M. Tech.
Power and Industrial Drives

(Duration of Study : 2 years)

GMRIT
Training Tomorrow's Engineers Today

Department of Electrical & Electronics Engineering
GMR Institute of Technology
Rajam, Andhra Pradesh
(An Autonomous Institute Affiliated to JNTU Kakinada, AP)
NBA Accredited and NAAC Accredited

The Vision of GMRIT

- To be among the most preferred institutions for engineering and technological education in the country
- An institution that will bring out the best from its students, faculty and staff – to learn, to achieve, to compete and to grow – among the very best
- An institution where ethics, excellence and excitement will be the work religion, while research, innovation and impact, the work culture

The Mission of GMRIT

- To turnout disciplined and competent engineers with sound work and life ethics
- To implement outcome based education in an IT-enabled environment
- To encourage all-round rigor and instill a spirit of enquiry and critical thinking among students, faculty and staff
- To develop teaching, research and consulting environment in collaboration with industry and other institutions

Department Vision

To be a most preferred Electrical & Electronics Engineering department of learning for students and teachers alike, with dual commitment to research and serving students in an atmosphere of innovation and critical thinking.

Department Mission

- To provide high-quality education in Electrical & Electronics Engineering, to prepare the graduates for a rewarding career in Electrical & Electronics Engineering and related industries, in tune with evolving needs of the industry.
- To prepare the students to become thinking professional and good citizens who would apply their knowledge critically and innovatively to solve professional and societal problems.

Program Educational Objectives (PEOs)

- PEO1: Graduates with ability to solve core engineering problems through continuous self-paced learning in tune with changing technologies
- PEO2: Reinforce engineering skills, critical thinking and problem-solving skills in professional engineering practices and deal with socio-economical, technical and business challenges
- PEO3: Nurture professionalism with soft skills, managerial & leadership skills and ethical values.

Program Outcomes (POs):

Engineering graduate will be able to:

PO 1: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems. (Engineering knowledge)

PO 2: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. (Problem analysis)

PO 3: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. (Design/development of solutions)

PO 4: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. (Conduct investigations of complex problems)

PO 5: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. (Modern tool usage)

PO 6: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. (The engineer and society)

PO 7: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. (Environment and sustainability)

PO 8: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. (Ethics)

PO 9: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. (Individual and team work)

PO10: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. (Communication)

PO 11: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. (Project management and finance)

PO 12: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. (Life-long learning)

Department of Electrical & Electronics Engineering
Power and Industrial Drives

[Minimum Credits to be earned: 68]

First Semester						
S. No	**Course Code**	**Course**	**Periods**			
			L	**T**	**P**	**C**
1	21MEX101	Advanced Optimization Techniques	4	-	-	4
2	21PID101	Analysis of Power Electronic Converters	4	-	-	4
3		Elective I	4	-	-	4
4		Elective II	4	-	-	4
5		Elective III	4	-	-	4
6	21PID102	Power Electronics and DC Drives Lab		-	3	1.5
7	21PID103	Term Paper		-	3	1.5
		Total	20	-	6	23
Second Semester						
1	21PID201	Electrical Machine Modeling and Analysis	4	-	-	4
2	21PID202	Switched Mode Power Conversion	4	-	-	4
3		Elective IV	4	-	-	4
4		Elective V	4	-	-	4
5		Elective VI	4	-	-	4
6	21PID203	Advanced Electrical Drives Lab		-	3	1.5
7	21PID204	Power Electronic Systems Simulation Lab		-	3	1.5
		Total	20	-	6	23
Third Semester						
1	21PID301	Internship	-	-	-	4
2	21PID302	Project	-	-	-	-
3	21PID303	Research Methodology and IPR (Audit Course)	-	-	-	0
		Total	-	-	-	4
Fourth Semester						
1	21PID302	Project	-	-	-	18

List of Elective Courses

S.No.	Course Code	Course Name	Periods			
			L	T	P	C
Elective I						
1	21PID001	DSP Applications to Drives	4	-	-	4
2	21PID002	Modern Control Theory	4	-	-	4
3	21PID003	Power Electronic Applications to Power Systems	4	-	-	4
Elective II						
4	21PID004	Power Electronics Applications for Renewable Energy Systems	4	-	-	4
5	21PID005	Power Semiconductor Devices & Protection	4	-	-	4
6	21PID006	Special Machines and Controls	4	-	-	4
Elective III						
7	21PID007	Power Electronic Control of DC Drives	4	-	-	4
8	21PID008	Industrial Sensors and Actuators	4	-	-	4
9	21PID009	Advanced Power Electronics	4	-	-	4
Elective IV						
10	21PID010	Computer Control of Industrial Drives	4	-	-	4
11	21PID011	Intelligent applications to Electric Drives	4	-	-	4
12	21PID012	PLCs & SCADA	4	-	-	4
Elective V						
13	21PID013	HVDC Transmission	4	-	-	4
14	21PID014	Modeling & Simulation of Power Electronic Systems	4	-	-	4
15	21PID015	Power Quality Issues & Mitigation	4	-	-	4
Elective VI						
16	21PID016	Power Electronics Control of AC Drives	4	-	-	4
17	21PID017	Flexible AC Transmission Systems	4	-	-	4
18	21PID018	Electrical Drives and Controllers for Electric Vehicles	4	-	-	4

21MEX101 Advanced Optimization Techniques

4 0 0 4

Course Outcomes

1. Design of mechanical systems and interdisciplinary engineering applications and business solutions using suitable optimization technique
2. Apply numerical or iterative techniques in power systems for optimal power flow solutions
3. Optimize the parameters in control systems for desired steady state or transient response
4. Optimize the cost function in deciding economic factors of power systems
5. Design of electrical systems optimally using suitable techniques like univariate method, steepest descent method etc.
6. Design of electrical systems optimally using steepest and descent method etc.

Unit I

Linear programming and Assignment Problem

Linear programming-Two-phase simplex method, Big-M method, duality, interpretation, applications, Assignment problem- Hungarian's algorithm, Degeneracy, applications, unbalanced problems, traveling salesman problem

Applications of assignment problems

15 Hours

Unit II

Classical and Numerical Optimization Techniques

Classical optimization techniques-Single variable optimization with and without constraints, multi–variable optimization without constraints, multi–variable optimization with constraints–method of Lagrange multipliers, Kuhn-Tucker conditions.

Numerical methods for optimization-Nelder Mead's Simplex search method, Gradient of a function, Steepest descent method, Newton's method, types of penalty methods for handling constraints

Exterior penalty function method for handling constraint

15 Hours

Unit III

Genetic algorithm and Programming

Genetic algorithm (GA)-Differences and similarities between conventional and evolutionary algorithms, working principle, reproduction, crossover, mutation, termination criteria, different reproduction and crossover operators, GA for constrained optimization, draw backs of GA.

Genetic Programming (GP)-Principles of genetic programming, terminal sets, functional sets, differences between GA & GP, random population generation, solving differential equations using GP

Solving differential equations using GP

15 Hours

Unit IV

Multi-Objective GA

Multi-Objective Pareto's analysis, non-dominated front, multi–objective GA, Non-dominated sorted GA, convergence criterion, applications of multi-objective problems

Basic Problem solving using Genetic algorithm, Genetic Programming & Multi Objective GA and simple applications of optimization for engineering systems

Simple applications of optimization for engineering systems

15 Hours

Total=60 Hours

Textbook (s)

1. J.S. Arora, Introduction to Optimum Design, McGraw Hill International Ed., NY, 1989
2. K. Deb, Optimization for Engineering Design: Algorithms and Examples, 2ndEd., PHI, 1995
3. S.S.Rao, Engineering Optimization: Theory and Practice, New Age International (P) Ltd., 2001

Reference (s)

1. D. E. Goldberg, Genetic Algorithms in Search and Optimization, Pearson publication, 1990
2. J. R. Koza, Genetic Programming, MIT Press, 1993
3. K. Deb, Multi-Objective Optimization Using Evolutionary Algorithms, Wiley, 2001

21PID101 Analysis of Power Electronic Converters

4 0 0 4

Course Outcomes

1. Outline the concepts and techniques used in power electronics circuits.
2. Select appropriate power converter topologies and design the power stage with controllers for various applications.
3. Apply advanced modulation techniques for analyzing and designing power converters
4. Design the single-phase power factor correction (PFC) circuits to draw sinusoidal currents at unity power factor.
5. Extend knowledge about the concepts of multilevel inverter.
6. Learn the role of Power Electronics in utility-related applications which are becoming extremely important.

Unit I

AC-DC Converters

Single Phase AC-DC Converters: Single phase Half controlled and Fully controlled Converters with RL load–Evaluation of input power factor and harmonic factor-Continuous and Discontinuous load current-Power factor improvements-Extinction angle control-symmetrical angle control-PWM single phase sinusoidal PWM-Single phase series converters

Three Phase AC-DC Converters: Three Phase ac-dc Converters- Half controlled and fully controlled Converters with RL load–Evaluation of input power factor and harmonic factor-Continuous and Discontinuous load current-three phase dual converters-three phase PWM-twelve pulse converters.

Power factor improvements

16Hours

Unit II

AC Voltage Converters

Single Phase AC voltage Controllers: Single Phase AC Voltage Controllers with RL and RLE loads-ac voltage controller's with PWM control-Effects of source and load inductances –synchronous tap changers –Application. Three Phase AC Voltage Controllers: Three Phase AC Voltage controllers-Analysis of Controllers with star and delta connected resistive, resistive –inductive loads–Application

Effects of source and load inductances

14Hours

Unit III

PWM Inverters

Single phase PWM Inverters: Principle of operation-Voltage control of single-phase inverters- sinusoidal PWM–modified PWM–phase displacement Control–Trapezoidal, staircase, stepped, harmonic injection and delta modulation

Three Phase PWM Inverters: Voltage Control of Three-Phase Inverters- Sinusoidal PWM- Third Harmonic PWM-Space Vector Modulation- Comparison of PWM Techniques-Variable dc link inverter.

Current source inverters

13Hours

Unit IV

Power Factor Correction Converters & Multi-Level inverters

Power Factor Correction Converters: Single-phase single stage boost power factor corrected rectifier, power circuit principle of operation, and steady state- analysis, three phase boost PFC converter.

Multi-Level inverters: Introduction, Multilevel Concept, Types of Multilevel Inverters- Diode-Clamped Multilevel Inverter, Principle of Operation, Features of Diode-Clamped Inverter, Improved Diode-Clamped Inverter- Flying-Capacitors Multilevel Inverter- Principle of Operation, Features of Flying-Capacitors Inverter- Comparisons of Multilevel Converters.

Cascaded Multilevel Inverter

17Hours

Total=60Hours

Textbook (s)

1. JMd.H.Rashid, Power Electronics, Pearson Education, 3rdEd.,2008
2. Ned Mohan Tore, M.Undelan, Power Electronics, William P.Robbins, John Wiley & Sons, 3rdEd.,2003.

Reference (s)

1. C. W. Lander, Power Electronics, McGraw Hill companies, 2ndEd., 1993.
2. G. K. Dubey, S. R. Doradra, A. Joshi and R. M. K. Sinha, Thyristorised Power Controllers, New Age International (P) Limited Publishers, 1996.
3. B. K. Bose, Modern Power Electronics: Evolution, Technology and applications, Jaico Publishing House, 1999.

21PID102 Power Electronics & DC Drives Lab

0 0 3 1.5

Course Outcomes

1. Illustrate the procedure for representing magnetization characteristics of DC shunt generator.
2. Interpret the efficiency of DC machine using various tests.
3. Demonstrate suitable method to find the performance characteristics of DC machine
4. Interpret various losses of DC machine by performing indirect tests.
5. Demonstrate suitable method to find the stray losses of a DC machine
6. Illustrate the procedure for implementing speed control methods for DC motors

List of Experiments

1 Gate firing circuits for SCR
2 Forced Commutation circuits (Class A, B, C, D & E)
3 Single phase fully controlled converter with R & RL Load
4 Single phase half-controlled converter with R & RL Load
5 Three Phase full Converter with R & R-L load
6 Three Phase semi-Converter with R & R-L load
7 Performance & speed control of DC drive using 3-phase full converter
8 Performance & speed control of DC drive using 3-phase semi-converter
9 Performance & Operation of a four quadrant Chopper on DC Drive
10 Speed control of DC motor using buck-boost regulator
11 Study on Industrial loads of HYPERSIM
12 Real time simulation of DC Motor Drive Using OPAL-RT OP5700

List of Augmented Experiments[1]

1. Generation of firing pulses using microcontrollers.
2. Design and fabrication of driver circuit for Power IGBT/MOSFET
3. Design of speed / current controller for DC drive system
4. Design of AC-DC/DC-DC Converters for green energy system

Reading Material (s)

1. P. S. Bimbra, “Electrical Machinery”, Khanna Publishers, 7th Edition, Color Reprint 2014.
2. I.J. Nagrath& D.P. Kothari, “Electric Machines”, Tata McGraw Hill, 5th Edition, 2017.
3. S. K. Sahdev, “Electrical Machines”, Cambridge University Press, 1st Edition, 2017

21PID201 Electrical Machine Modeling and Analysis

4 0 0 4

Course Outcomes

1. Summarize the model of all electrical machines in generalized machine theory.
2. Apply the modeling of dc and ac machines using Kron's primitive machine.
3. Apply modeling concept to all electrical machines to study the performance characteristics of machine.
4. Compare the performance of machine in actual and two phase (dq) platform.
5. Evaluate the performance characteristics of machine in dq-modeling.
6. Design and simulate all electrical machine models using simulation software.

Unit I

Basic concepts of modeling

Magnetically coupled circuits, Electro-magnetic energy conversion, Basic Two-pole Machine representation of Commutator machines, 3-phase synchronous machine with and without damper bars and 3-phase induction machine, Kron's primitive Machine-voltage, current and torque equations.

Apply Kron's theory for all electrical machines. Understand mathematical model of electrical machines

16 Hours

Unit II

DC Machine modeling

Mathematical model and transfer function of separately excited D.C motor, Steady State analysis, Transient State analysis-Sudden application of Inertia Load, Mathematical model of D.C Series & shunt motors.

Model all dc machines and execute them in simulated software

14 Hours

Unit III

Modeling of Three Phase Induction Machine

Transformation from Three phase to two phase and Vice Versa, Transformation from Rotating axis to stationary axis and vice versa-Park's Transformation and it's physical concept, inductance matrix, Mathematical model of Induction machine –Steady State analysis, d-q model of induction machine in Stator reference frame, Rotor reference frame and Synchronously rotating reference frame, Small signal model of induction machine, d-q flux linkages model derivation, Dynamic simulation of induction machine.

Model induction machines and simulate using Simulation tool

17 Hours

Unit IV

Modeling of Synchronous Machine

Synchronous machine inductances phase Co-ordinate model, Space phasor model-Steady state operation- d-q model of Synchronous machine, mathematical model of PM Synchronous motor.

Study the dynamic behavior of Synchronous machine using Simulation tool

13 Hours

Total=60 Hours

Textbook (s)

1. M. H. Rashid, Power Electronics, Pearson Education, 3rdEd.,2008
2. Ned Mohan Tore, M.Undelan, Power Electronics, William P. Robbins, John Wiley & Sons, 3rdEd., 2003.

Reference (s)

1. P. S. Bimbra, Generalized Theory of Electrical Machines, Khanna Publications, 5th Ed., 2002.
2. John Chiasson, Modeling and High Performance Control of Electric Machines, John Wiley & Sons, 2005.

21PID202 Switched Mode Power Conversion

4 0 0 4

Course Outcomes

1. Analyze Steady-State switched-mode dc-dc power converters
2. Analyze, Modeling, and Design the Inductors and Transformers for switched-mode power converters.
3. Solve the engineering problems related to switching converters
4. Design the Switched-Mode Converters, including selection of component values based on steady-state dc and ac ripple specifications
5. Analyze for Small-Signal ac Model Development and Analysis for switched-mode dc-dc converters using averaging techniques, including the derivation and visualization of converter small-signal transfer functions
6. Apply mathematics through differential equations in analyzing and designing switching converter circuits

Unit I

Single-Switch Isolated Converters and Push Pull Converters

Requirement for isolation in the switch-mode converters, transformer connection, Forward and fly back converters, power circuit and steady-state analysis.

Power circuit and steady-state analysis, utilization of magnetic circuits in single switch and push-pull topologies

Steady-state analysis push-pull converter

15 Hours

Unit II

Isolated Bridge Converters

Half bridge and full-bridge converters, Power circuit and steady-state analysis, utilization of magnetic circuits and comparison with previous topologies.

Formulation of dynamic equation of buck and boost converters, averaged circuit models, linearization technique, small-signal model and converter transfer functions.

Dynamic modeling of DC-DC Converters

15 Hours

Unit III

Controller Design and Resonant Converters

Review of frequency-domain analysis of linear time-invariant systems, concept of bode plot, phase and gain margins, bandwidth, controller specifications, proportional (P), proportional plus integral (PI), proportional plus integral plus integral controller (PID), selection of controller parameters.

Classification of Resonant converters-Basic resonant circuits- Series resonant circuit-parallel resonant circuits-Resonant switches.

PID tuning methods-a review

16 Hours

Unit IV

Quasi-Resonant Converters

Classification of Resonant converters-Basic resonant circuits- Series resonant circuit-parallel resonant circuits-Resonant switches.

Quasi-Resonant Converters-I Concept of Zero voltage switching, principle of operation, analysis of M-type and L-type Buck or boost Converters.

Quasi-Resonant Converters-II Concept of Zero current switching, principle of operation, analysis of M-type and L-type Buck or boost Converters.

Design of Resonant Converter

14 Hours

Total=60 Hours

Textbook (s)

1. Robert Erickson and Dragon Maksimovic, Fundamentals of Power Electronics, Springer Publications, 2001.
2. Issa Batarseh, Power Electronics, John Wiely, 2004.

Reference (s)

1. Philip T. Krein, Elements of Power Electronics, Oxford University Press, 2015.
2. L.Umanand, Power Electronics: Essentials &applications, Tata Mc-Graw Hill, 2009.

21PID203 Advanced Electrical Drives Lab

0 0 3 1.5

Course Outcomes

1 Illustrate the use of different types of controllers to regulate the electrical drives
2 Analyze the performance and speed control methods of modern electrical drives
3 Demonstrate the working and performance of AC-AC converters
4 Demonstrate the working and performance of DC-AC converters
5 Demonstrate the PWM pulse generation for converters
6 Develop the real time simulation model for the AC drive

List of Experiments

1 Performance & Operation of a 3-phase AC Voltage controller on motor load.
2 Single Phase IGBT based PWM Inverter with R & R-L load
3 Single Phase Parallel inverter with R and RL loads
4 Single Phase cyclo-converter with R and RL loads
5 Single Phase series inverter with R and RL loads.
6 Operation of 3-phase IGBT based PWM Inverter with R & R-L load.
7 Performance & speed control of PMSM motor using DSP controller.
8 Performance & speed control of BLDC motor using DSP controller.
9 Three phase PWM Pulse generation using PIC Micro controller.
10 PIC Microcontroller based speed control of three phase Induction Motor
11 DSP based V/F Control of 3 phase Induction motor
12 Performance & speed control of reluctance motor using DSP/dsPIC controller
13 Realization of control logic for electric motors using FPGA controller
14 Micro controller-based speed control of Stepper motor
15 Real time simulation of AC Motor Drive Using OPAL-RT OP5700

List of Augmented Experiments[2]

1 PWM pulse generation using low-cost PIC /Aurdino controller for the three-phase inverter.
2 Design speed /current controller for special electrical machines.
3 Design of multilevel converter for green energy system
4 Design open / closed loopcontroller for AC drives.

Reading Material (s)

1. B.K.Bose, Modern Power Electronics and AC Drives, Pearson, 1st edition, 2015.
2. M.D. Singh & K.B. Kanchandhani, "Power Electronics", Tata Mc Graw Hill Publishing Company, 2nd Edition, 2017.
3. OPAL-RT: https://www.opal-rt.com/software-software-overview/fpga-electric-machine-library/

21PID204 Power Electronic Systems Simulation Lab

0 0 3 1.5

Course Outcomes

1 Make use of the simulation tools for solving complex engineering problems.
2 Design and simulate the AC to DC and DC to DC converters
3 Design and simulate the AC to AC and DC to AC converters
4 Develop the simulation circuit to measure the performance parameters
5 Design and simulate the speed controller for AC drives.
6 Design and simulate the speed controller for DC drives.

List of Experiments

1 Simulation of single-phase full converter with RL & RLE load
2 Simulation of single-phase semi converter with RL & RLE load
3 Simulation of single-phase AC Voltage controller with RL load.
4 Simulation of three phase AC voltage controller.
5 Simulation of dc-dc buck, boost and buck-boost converter.
6 Simulation of single-phase inverter using sinusoidal PWM control.
7 Simulation of three phase inverter using sinusoidal PWM control.
8 Simulation of diode-clamped multilevel inverter fed induction motor
9 Calculate the displacement power factor, power factor and the total harmonic distortion associated with the power-electronics interface.
10 Simulation of power factor correction converter.
11 Simulation of the speed controller for DC motor drive
12 Simulation of the speed controller for induction motor drive
13 Modelling and simulation of synchronous motor drive

List of Augmented Experiments[3]

1 Simulation model of speed controller for the special electrical machines
2 Simulation of cascaded H-bridge inverter
3 Simulation of half-bridge LLC resonant converter
4 Simulation of capacitor-clamped inverter

Reading Material (s)

1. M. H. Rashid, “Power Electronics: Circuits, Devices and Applications”, Prentice Hall of India, 4th Edition, 2017
2. P.S. Bhimbra, “Power Electronics”, Khanna Publishers, 5th Edition, 2018.
3. Bimal K Bose, “Power Electronics in Renewable Energy Systems and Smart Grid”, IEEE Press and John Wiley & Sons, 2019.

21PID001 DSP Applications to Drives (Elective–I)

4 0 0 4

Course Outcomes

1. Identify suitable DSP processor for practical applications.
2. Outline the Input-output functionality and operation of ADC.
3. Design PWM Signal Generation with Event Managers.
4. Propose speed control methods using DSP controller for an Electrical drive.
5. Develop program for DSP for a given application.
6. Design the hardware interface for DSP controller for a given application.

Unit I

Introduction to the TMSLF2407 DSP controllers

Introduction to the TMSLF2407, DSP controller- Types of Physical Memory-C2XX DSP CPU and Instruction set-Introduction-Generation- Mapping External Devices to the C2xx Core.

Peripheral Interface with DSP controller

15 Hours

Unit II

General Purpose Input/output (GPIO) Functionality

Assembly Programming-Multiplexing and General Purpose I/O Control Registers-Interrupts on the TMS320LF2407.

Assembly Programming for PWM

14 Hours

Unit III

Overview and Operation of the ADC

The Analog-to-Digital converter (ADC)-Overview and Operation of the ADC and programming modes-The Event managers (EVA, EVB).

PWM Signal Generation with Event Managers

13 Hours

Unit IV

Clarke's and park's transformations and machine control techniques

Clarke's and park's transformations: Implementation of Clarke's and Park's transformation, SV PWM, BLDC Motor Control System, Permanent magnet synchronous machines control system, Induction Motor Speed Control using LF2407 DSP

Vector control of Induction motor using DSP controller

18 Hours

Total=60 Hours

Textbook (s)

1. Hamid A. Tolyat and Steven G. Campbell, DSP Based Electro Mechanical Motion Control, CRC press, 2004.
2. Application Notes from the webpage of Texas Instruments,2003

Reference (s)

1. Bar Ba C, Programming and Application of a DSP to Control and Regulate Power Electronic Converters: Programming in C++, Anchor Academic Publishing, 2014.
2. Tze-Fun Chan, Keli Shi, Applied Intelligent Control of Induction Motor Drives, Wiley-Blackwell, 2011.

21PID002 Modern Control Theory (Elective–I)

4 0 0 4

Course Outcomes

1. Develop state-space models.
2. Design state feedback controller and observer.
3. Analyze non-linear control systems using phase plane & describing functions.
4. Analyze the stability of Non-linear control systems using different techniques.
5. Design optimal controllers.
6. Design Linear Quadratic Regulator for a given system

Unit I
State Variable Analysis
Concept of state–State Variable and State Model–State models for linear and continuous time systems–Solution of state and output equation–controllability and Observability- Pole Placement, Ackerman's formula
State observers- Reduced and full order observers

15 Hours

Unit II
Non-Linear Systems
Features of linear and non-linear systems-Common physical non-linearities–Methods of linearizing non-linear systems-Concept of phase portraits–Singular points–Limit cycles–Construction of phase portraits–Phase plane analysis of linear and non-linear systems–Isocline method. Derivation of describing functions for common non-linearities.
Describing function analysis of non-linear systems

15 Hours

Unit III
Stability Analysis
Stability in the sense of Lyapunov. Lyapunov's stability and Lypanov's instability theorems. Direct method of Lypanov for the Linear and Nonlinear continuous time autonomous systems, Construction of Lyapunov functions using Krasovskii and Variable Gradient Method.
Stability Analysis of Nonlinear system

15 Hours

Unit IV
Optimal Control
Problem formulation, necessary conditions of optimality, state regulator problem. Matrix Riccati equation, infinite time regulator problem, output regulator and tracking problems. Linear Quadratic Regulator, model matching based on Linear Quadratic optimal regulator.
Dynamic programming

15 Hours
Total=60 Hours

Textbook (s)

1. I. J. Nagrath and M. Gopal, Control Systems Engineering, New Age International (P) Limited, 5th Ed., 2004.
2. Katsuhiko Ogata, Modern Control Engineering, Prentice Hall of India Pvt. Ltd., 5thEd., 2010.

Reference (s)

1. Benjamin C. Kuo, Automatic Control Systems, John Wiley & Sons, 8th Ed., 2002.
2. M. Gopal, Modern control system theory, New Age International Publishers, 4th Ed., 2002.

16PID003 Power Electronic Applications to Power Systems (Elective–I)

4 0 0 4

Course Outcomes

1. Demonstrate the importance of reactive power and voltage stability
2. Analyze the performance of shunt controllers and reactive power injection
3. Analyze the performance of series FACTS controllers and compare their performances
4. Evaluate the performance of voltage and Phase Angle Regulators
5. Demonstrate the operation and evaluate the performance of UPFC
6. Compare various PWM techniques

Unit I

Introduction to Power System

General System Considerations, Transmission Interconnections, flow of power in AC systems, Loading capability, power flow and Dynamic Stability considerations of a transmission interconnections, Relative importance of controllable parameters. Basic types of FACTS Controllers, Benefits from FACTS technology, HVDC versus FACTS. Limitations of load balancing using passive elements, Use of VSI as a VAR generator, indirect current controlled synchronous link converter VAR Compensator (SLCVC).

Various PWM techniques: Harmonic Elimination- Theory and implementation issues. Discussion on bi-directional power flow in VSI, Use of VSI as active filter cum Var generator.

Reactive power compensator using instantaneous reactive power theory

15 Hours

Unit II

Static Shunt compensators

Objectives of Shunt compensation, Methods of controllable VAR generation-TCR, TSC, FC-TCR, TSC-TCR, STATCOM.

Hybrid VAR generator

15 Hours

Unit III

Series Compensators

Objectives of series compensation, Variable impedance type series compensators-GCSC, TSSC, TCSC and SSSC, Switching converter type series compensators.

Closed loop operation of Series compensator

14 Hours

Unit IV

Static Voltage Regulators

Objectives of voltage and Phase Angle Regulators, Thyristor Controlled Phase Angle Regulators, Switching converter based Phase Angle Regulators.

Unified Power Flow Controller (UPFC), Control capabilities of UPFC.

2-port representation of UPFC

16 Hours

Total=60 Hours

Textbook (s)

1. Narain G. Hingorani and Laszlo Gyugyi, Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems, Standard Publishers, New Delhi, 2001.
2. R. Mohan Mathur and Rajiv K. Varma, Thyristor Based FACTS Controller for Electrical Transmission Systems, Wiley Interscience Publications, 2002.
3. K. R. Padiyar, Facts Controllers in Power Transmission & Distribution, New Age International (P) Ltd., 2007.

Reference (s)

1. E. Acha, V. G. Agelidis, O.Anaya-Lara and T. J. E. Miller, Power Electronic Control in Electrical Systems, Newnes Power Engineering Series, Oxford, 2002.
2. T. J. E. Miller, Reactive power control in Electrical system, John Wiley & Sons, 1982.

21PID004 Power Electronics Applications for Renewable Energy Systems (Elective–II)

4 0 0 4

Course Outcomes

1. Outline the impacts of renewable energy generation on Environment
2. Explain principle of operation and analysis of wind electrical generators
3. Select the different inverters ,battery sizing and array sizing
4. Design different power converters for wind energy systems
5. Compare the Stand alone operation of fixed and variable speed wind energy conversion systems and solar system
6. Discuss need for Hybrid Systems and its ranges

Unit I

Introduction

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

Hybrid renewable energy systems

15 Hours

Unit II

Electrical Machines for Renewable Energy Conversion

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

DFIG for wind power generation

15 Hours

Unit III

Power Converters

Solar: Block diagram of solar photo voltaic system-Principle of operation: line commutated converters (inversion-mode)–Boost and buck-boost converters- selection of inverter, battery sizing, array sizing Wind: three phase AC voltage controllers- AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, Grid Interactive Inverters.

Matrix converters

16 Hours

Unit IV

Analysis of Wind and PV Systems

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

Hybrid Renewable Energy Systems-Need for Hybrid Systems- Range and type of Hybrid systems- PV- Maximum Power Point Tracking (MPPT).

Case studies on renewable Energy systems

14 Hours

Total=60 Hours

Textbook (s)

1. M. H. Rashid, Power electronics Hand book, Academic press, 2001.
2. G.D. Rai, Nonconventional energy sources, Khanna publishes, 1993.
3. G.D. Rai, Solar energy utilization, Khanna publishes, 1993.

Reference (s)

1. Gray, L. Johnson, Wind energy system, prentice hall link, 1995.
2. B. H. Khan, Non-conventional Energy sources, Tata McGraw-hill Publishing Company, New Delhi, 2009

21PID005 Power Semiconductor Devices & Protection (Elective–II)

4 0 0 4

Course Outcomes

1. Describe the Power semiconductor device selection strategy and On-state and switching losses.
2. Illustrate the characteristics and operating principles of Current controlled devices.
3. Illustrate the characteristics and operating principles of Voltage controlled devices.
4. Select suitable Firing scheme for Semiconductor devices.
5. Design protection schemes for Semiconductor devices using snubber circuits
6. Illustrate thermal characteristics and cooling techniques for various power electronic devices

Unit I

Introduction

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

Ratings of Power diodes

13 Hours

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 & Thyristors

17 Hours

Unit III

Voltage Controlled Devices

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

Construction of GTO

14 Hours

Unit IV

Firing and Protecting Circuits

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

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.

Optoisolator

16 Hours

Total=60 Hours

Textbook (s)

1. B.W Williams, Power Electronics Circuit Devices and Applications, McGraw-Hill, 2nd Ed., 1992.
2. M.H Rashid,Power Electronics Circuits, Devices and Applications, Prentice Hall India, 3rdEd., New Delhi, 2004.

Reference (s)

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

21PID006 Special Machines and Controls (Elective–II)

4 0 0 4

Course Outcomes

1. Analyze the characteristics of different types of PM type Brushless DC motors and to design suitable controllers
2. Apply the knowledge of sensors used in PMSM which can be used for controllers and synchronous machines.
3. Evaluate the steady state and transient behavior Linear induction motors
4. Analyze the different controllers used in electrical machines to propose the suitability of drives for different industrial applications
5. Classify the types of Linear motors and apply the knowledge of controllers to propose their applications in real world.
6. Develop the control method for given special machine.

Unit I
Switched Reluctance Motor

Principle of operation, design of stator and rotor pole arc, Power Converter for switched reluctance motor.
Stepper Motors-Construction, principle of operation, theory of torque production, hybrid stepping motor, variable reluctance stepping motor.
Linear Induction Motor=Construction, principle of operation, application of linear induction drive for electric traction.
Linear Synchronous motor and its applications

18 Hours

Unit II
PMSM & BLDC motors

Brushless DC Motor-Construction, principle of operation, theory of brushless DC Motor as variable speed synchronous motor.
Permanent Magnet Motors-Hysteresis loop, Permanent Magnet DC Motors, equivalent circuit, electrically commutated DC Motor.
Torque ripple minimization

15 Hours

Unit III
Control of special Machines

Stepper motors (open loop control, closed loop control). Characteristics of stepper motor in open –loop drive. Comparison of open loop and closed loop systems. Control of switched reluctance motor for fraction type load. Control of brushless dc motor, rotor position sensing and switching logic for brushless dc motor.
Sensorless control method –review

16 Hours

Unit IV
Traction Drives

Electric Motors for traction drive- AC motors, DC motors, and single sided linear induction motor for traction drives, Comparison of AC and DC traction.
Linear Synchronous motor operation

11 Hours
Total=60 Hours

Textbook (s)

1. P. C. Krause, Analysis of Electrical Machinery, Mc-Graw Hill, 1st Ed., 1980.
2. R. Krishnan, Electric Motor Drives Modeling, Analysis & Control, Pearson Education, 1st Ed., 2002.

Reference (s)

1. P. S. Bimbra, Generalized Theory of Electrical Machines, Khanna Publications, 5th Ed., 2002.
2. John Chiasson, Modeling and High Performance Control of Electric Machines, John Wiley & Sons, 2005

21PID007 Power Electronic Control of DC Drives (Elective–III)

4 0 0 4

Course Outcomes

1. Outline the speed control and braking methods of electrical drives for day to day applications.
2. Propose various controlling techniques of dc drive for industrial applications.
3. Design various power electronic converters to control the dc motor.
4. Design speed controller for converter fed dc drive.
5. Summarize the performance characteristics of converter fed and chopper fed DC motors to justify their applications.
6. Select suitable converter for dc and ac drives.

Unit I

Speed Torque characteristics of DC Motors

Separately excited DC motors, Shunt motor, series motor and compound motor Controlled Bridge Rectifier (1-Φ) with DC Motor Load Separately excited DC motors with rectified single phase supply-single phase semiconverter and single phase full converter for continuous and discontinuous modes of operation–power and power factor.

Harmonic Analysis in converter

15 Hours

Unit II

Controlled Converters

Controlled Bridge Rectifier (3-Φ) with DC Motor Load Three phase semi converter and three phase full converter for continuous and discontinuous modes of operation –power and power factor –Addition of Freewheeling diode.

Three phase naturally commutated bridge circuit as a rectifier or as an inverter Three phases Controlled bridge rectifier with passive load impedance, resistive load and ideal supply–Highly inductive load and ideal supply for load side and supply side quantities, shunt capacitor compensation, three phase controlled bridge rectifier inverter. *Harmonic Analysis in inverter*

15 Hours

Unit III

Closed loop control of phase controlled DC motor Drives

Open loop Transfer functions of DC Motor drive-Closed loop Transfer function of DC Motor drive Chopper controlled DC motor drives-Principle of operation of the chopper–Four quadrant chopper circuit– Chopper for inversion–Chopper with other power devices–model of the chopper–input to the chopper–Steady state analysis of chopper controlled DC motor drives –rating of the devices

Phase-Locked loop control

16 Hours

Unit IV

Closed loop control of chopper fed DC motor Drives

Speed controlled drive system–current control loop–pulse width modulated current controller–hysteresis current controller –modeling of current controller –design of current controller

Simulation of DC motor Drives-Dynamic simulations of the speed controlled DC motor drives –Speed feedback speed controller–command current generator –current controller.

Simulation of the speed controlled DC motor drive using MATLAB

14 Hours

Total=60 Hours

Textbook (s)

1. Gopal K. Dubey, Fundamentals of Electric Drives, Narosa Publications, 2nd Ed., 2001.
2. R. Krishnan, Electrical drives: Modeling, Analysis and Control, Prentice Hall of India., 1st Ed., 2007.

Reference (s)

1. Shepherd, Hulley and Liang, Power Electronics and Motor Control, Cambridge University Press, 1995.
2. M. H. Rashid, Power Electronic Circuits, Devices and Applications, 3rd Ed, Prentice Hall of India, 2004.

21PID008 Industrial Sensors and Actuators (Elective–III)

4 0 0 4

Course Outcomes

1. Understand how different physical variables are measured and illustrate their working principles.
2. Identify and select proper sensors for specific applications.
3. Understand issues of implementation of different sensors including calibration and error analysis.
4. Familiar with the basics of various actuators.
5. Model linear actuators and differentiate various solenoids.
6. Explain the working principle of different types of rotary actuators.

Unit I

Introduction to Sensors

Definition, Measurement Techniques, Classification of errors, Error analysis, Static and dynamic characteristics of transducers, Performance measures of sensors, Classification of sensors, calibration techniques.

Temperature Sensors: Thermoresistive, Resistance Temperature Detectors, Silicon Resistive, Thermistors, Semiconductor, Optical, Acoustic, Piezoelectric.

Position, Displacement and level sensors, Velocity and Acceleration Sensors.

Case study in manufacturing industries.

15 Hours

Unit II

Chemical and Modern Sensors:

Metal Oxide Chemical, Chem FET, Electrochemical, Potentiometric, Conduct metric, Amperometric, Optical Chemical, Mass Detector.

Film sensors, micro-scale sensors, Particle measuring systems, Vibration Sensors, SMART sensors, Machine Vision, Multi-sensor systems.

Case study in processing Industries

15 Hours

Unit III

Electrical Actuating systems

DC motors: Principle of operation, Performance, Efficiency and characteristics, Application as Actuator. Stepper Motors: Principle of operation, Performance, Efficiency and characteristics, Application as Actuator. Induction motors: Principle of operation, Performance, Efficiency and characteristics, Application as Actuator

Linear Actuators: Voice Coil Actuators, solenoids.

Applications of Linear Actuators in industry

15 Hours

Unit IV

Pneumatic and Hydraulic actuating systems

Components of pneumatic and hydraulic systems, pumps, compressor, filter, control valves, pressure regulation, relief valves, accumulator. Rotary Actuators: Disk Rotary Actuators, Claw Pole Rotary Actuators.

Applications of Rotary Actuators in industry

15 Hours

Total=60 Hours

Textbook (s)

1. Jacob Fraden, “Handbook of Modern Sensors, physics, design and applications”, Fourth edition, Springer, 2010.
2. Patranabis D.,” *Sensor and Actuators*”, Prentice Hall of India (Pvt) Ltd., 2nd edition, 2005.
3. Clarence W Silva, “*Sensors and Actuators: Control System Instrumentation*”, CRC Press, 1st edition, 2007.

Reference (s)

1. Andrzej M Pawlak, “*Sensors and Actuators in Mechatronics: Design and Applications*”, CRC Press, 2006.
2. E.O. Doebelin, “*Measurement Systems: Application and Design*”, McGraw Hill Higher Education, 4th edition, 1990.

21PID009 Advanced Power Electronics (Elective–III)

4 0 0 4

Course Outcomes

1. Explain the operation of switch-mode power electronic converters
2. Analyze the performance parameters of resonant converters
3. Examine the benefits of soft-switching in power electronic converters
4. Contrast multilevel and modular power electronic converters
5. Select appropriate phase shifting converter for a multi-pulse converter
6. Design power electronic converter for a given application

Unit I

Switching Voltage Regulators

Introduction; Linear power supply (voltage regulators); Switching voltage regulators; Review of basic dc-dc voltage regulator configurations -Buck, Boost, Buck-Boost converters and their analysis for continuous and discontinuous mode; Other converter configurations like Flyback converter, Forward converter, Half bridge, Full bridge configurations, Push-pull converter, Sepic Converter

Multi-output switch mode regulator

15 Hours

Unit II

Resonant Converters

Introduction, Need of resonant converters, Classification of resonant converters, Load resonant converters, Resonant switch converters, zero-voltage switching dc-dc converters, zero current switching dc-dc converters

Clamped voltage topologies

15 Hours

Unit III

Multi-level Converters

Need for multi-level inverters, Concept of multi-level, Topologies for multi-level: Diode Clamped, Flying capacitor and Cascaded H-bridge multilevel converters configurations; Features and relative comparison of these configurations applications.

Carrier based PWM technique for multi-level converters

15 Hours

Unit IV

Multi-pulse Converters

Concept of multi-pulse, Configurations for m-pulse (m=12,18,24 ….) converters, Different phase shifting transformer (Y-Δ1, Y- Δ2, Y-Z1 and Y-Z2) configurations for multi-pulse converters.

Advantages & applications of Multi-pulse Converter

15 Hours

Total=60 Hours

Textbook (s)

1. Ned Mohan, Tore M. Undeland and William P. Robbins, "*Power Electronics –Converters, Applications and Design*", John Willey & sons, Inc., 3rd edition. 2003.
2. Muhammad H. Rashid, "*Power Electronics -Circuits, Devices and Applications*", Prentice Hall of India, 3rd edition., 2009.
3. P. C. Sen, "*Modern Power Electronics*", S. Chand and Co. Ltd., New Delhi, 2000.

Reference (s)

1. Muhammad H. Rashid, "*Power Electronics Handbook*", Elsevier, 3rd edition., 2011.
2. L. Umanand, "*Power Electronics Essentials and Applications*", Tata Mc-Graw Hill, 2009.

21PID010 Computer Control of Industrial Drives (Elective–IV)

4 0 0 4

Course Outcomes

1. Outline the architectural features of microcomputers
2. Interpret digital implementation of drives control
3. Analyze different types of compensators, digital firing schemes for power electronic devices
4. Illustrate microcontrollers and microcomputers for the control of AC/DC drives
5. Make use of microcomputers for the control of conventional and special machines
6. Solve and use power electronic devices for control of drives

Unit I

Microcomputer Control & Compensators

Merits and demerits of Microcomputer Control of Electric Drives, Simplified sequence control diagram, Control system design stages, Computer loading factor, simplified structure of software and task timing diagram, Digital implementation of PI Compensator, Lag-Lead Compensator.

Digital implementation of Static Slip recovery scheme

14 Hours

Unit II

AC & DC Drives & Digital Firing Schemes

The Microcomputers adopted for control of electrical drives, relative features and architecture, Review of power converters useful for DC and AC drives, Current speed sensing, Zero crossing detector, Position sensing circuits required for microprocessor based control.

Different types of Digital firing schemes for converters, Chopper and Inverter circuits, DC drive control, Induction motor drive control.

Variable frequency synchronous motor drives

16 Hours

Unit III

Microcomputer Control of Converters

Microcomputer control of converter-fed DC motor drives (Digital Leonard control system), Automatic current regulating loop, automatic speed regulating loop and over all algorithm, Basic principle of vector control of Induction motors, phasor diagram and digital block diagram

Microcomputer control of vector control of Induction motor

14 Hours

Unit IV

Microcomputer Control of Motor Drives

Optimal efficiency drive of Induction motor with VIF control, Microcomputer control of current source fed synchronous motor drive, digital firing circuit, optical encoder, four quadrant operation of synchronous motor drive. Microcomputer of control of sensorless brushless motor drive control, vector control of synchronous motor drives.

Microcomputer control of switched reluctance motors

16 Hours

Total=60 Hours

Textbook (s)

1. Bimal K Bose, Microcomputer Control of Power Electronics and Drives, IEEE Press (Reprint), 2007.
2. Bimal K Bose, Power Electronics and Variable Frequency Drives Technology and Applications, Wiley, 2010.

Reference (s)

1. W. Leonard, Control of Electrical drives, Springer, 2001.
2. Fred C Lee, Power Electronics Technology and Applications II, IEEE Technology Update Series 2010.

21PID011 Intelligent Applications to Electric Drives (Elective–IV)

4 0 0 4

Course Outcomes

1. Demonstrate membership functions, basic concept of Fuzzy & their Inference systems
2. Apply fuzzy systems to DC drive for speed & current control
3. Infer fundamental concepts of Artificial Neural Networks
4. Compare various algorithms of Artificial Neural Networks
5. Analyze Steady state & Transient analysis of Induction Motor using ANN
6. Model & tryout Induction Motor using Fuzzy–Neural Network

Unit I

Fuzzy Logic Systems

General-Proven advantages of various industrial fuzzy logic applications-fuzzy logic system, fuzzy logic basics-classical set, characteristic function-classical set operations-fuzzy set, member ship function, fuzzy set operations-ns of fuzzy sets, the extinction principle, fuzzy rules, fuzzy reasoning-fuzzy logic inference system, Sugeno fuzzy logic inference system, Tsukamoto fuzzy logic inference system-fuzzy logic system design

Automatic generation of fuzzy rules from data-adaptive fuzzy logic systems

14 Hours

Unit II

Drive with Fuzzy Controllers

Drive with fuzzy speed controller- drive with fuzzy speed and armature current controller- drive with fuzzy speed, armature current and flux controller- drive with fuzzy firing angle compensation, fuzzy speed controller and armature current controller-drive scheme-linearization of converter non-linear characteristics-fuzzy firing angle compensator

Fuzzy speed and current controllers-simulation results

12 Hours

Unit III

Artificial Neural Networks

ANN fundamentals-biological neuron model, artificial neuron model, ANN networks-Hardware implementation of ANNs-various ANNs and training strategies for different applications-applications of the error back propagation algorithm-data preparation for the back propagation algorithm-nodes, layers- back propagation training and learning, learning curve-generalized data rule- application of simultaneous input vectors: batching- numerical acceleration techniques, avoidance of over fitting- Leven berg-Marquardt algorithm-unsupervised learning, competitive learning-main features of unsupervised learning and winner-take-all learning techniques- three computational stages of clustering- winner-take-all network initialization and weight adjustment algorithm-limitations of winner-take-all algorithm, all other algorithms-K F Mand other self-organizing techniques-lateral connections in a biological neural network- lateral connections in an artificial neural network: the Kohonen feature map-KMF learning algorithm, main characteristics.

ANN controller for DC motor

19 Hours

Unit IV

AI Based Steady-State and Transient Analysis of Induction Machines

Transient analysis-ANN based steady state and transient analysis-ANNs for slip-ring induction machine- ANNs for squirrel-cage induction machine- fuzzy-neural-network-based steady-state and transient analysis of induction machines-vector drive with self-organizing fuzzy-neural speed controller, experimental results and minimal configuration- vector drive with a neural speed controller, experimental results, and minimal configuration.

ANFIS based speed controller of induction motor

15 Hours

Total=60 Hours

Textbook (s)

1. Peter Vas, Artificial Intelligence Based Electrical Machine and Drives, Oxford University, 1999.
2. Teresa Orłowska-Kowalska, Frede Blaabjerg, José Rodríguez, Advanced and Intelligent Control in Power Electronics and Drives, Springer, 2014.

Reference (s)

1. Tze-Fun Chan, Keli Shi, Applied Intelligent Control of Induction Motor Drives, John-Wiley, 2011.

21PID012 PLCs & SCADA (Elective–IV)

4 0 0 4

Course Outcomes

1. Identify basic components of PLCs, their architecture &addressing modes.
2. Analyze different levels of File I / O & Ladder Logic diagram of PLCs.
3. Develop PLC based system for real time application.
4. Illustrate the programming concepts of PLCs.
5. Interface PLCs & SCADA for Industrial Automation.
6. Design various animations & alarming functions in SCADA.

Unit I

Introduction to Programmable Logic Controllers

Overview, Functions & Features, Typical areas of Application, PLC vs Personal Computers, PLC vs Dedicated Controllers, Logic Contact Symbology, Binary & Hexadecimal conversions, Input / output addressing.

Review on various PLC controllers

14 Hours

Unit II

PLC Hardware& System Configuration

Backplane & Rack, Power Supply Module, Programmable Controller, Discrete Input / output Modules, Analog Input / output Modules, Special Function Input/output Modules, Network Interface Modules, Serial Communication Interface, Memory modules, Proprietary Cables & accessories, Redundancy–overview, Introduction to Remote Input / outputs. Finalization of Input / output Module count, Rack Configuration, Power Supply Limits, Communication Limits, Input / Output allotment & addressing, Finalization of Derived Function Blocks.

Interfacing PC to PLC

15 Hours

Unit III

PLC Programming–Fundamentals & Implementation

Configuration, Ladder Logic (LD), Function Block Diagram (FBD), Instruction List (IL), Structured Text (ST), Sequential Function Chart (SFC), Arithmetic Functions, Logic Functions, Timers and Counters, Communication Instructions, Data Transfer Instructions, System Bits and Words, Function Blocks, Derived Function Blocks.

Configuration of Rack, Configuration of Controller, Configuration of Network Modules, Configuration of Input Output Modules, Structuring a program, Creation of database, Programmer's console, Downloading / Uploading Projects, PLC Modes (RUN, STANDBY, and MONITOR), Simulation & Testing, Loop tuning & Parameter setting, on line Monitoring / debugging, Diagnostic features. PLC Programming.

PID Function Blocks

16 Hours

Unit IV

Supervisory Control & Data Acquisition (SCADA)

Introduction to SCADA, SCADA Architecture, Communication table for signal exchange, Introduction to communication protocols, Creation of Database, Operating Screens, Application programming, Simulation / RUN time, Alarms, Trends & Bar graphs, Historical Data Management.

Interfacing with PLC

15 Hours

Total=60 Hours

Textbook (s)

1. Rajesh Mehra, Vikrant Vij,PLCs & SCADA: Theory &Practice, Laxmi Publications, 1st Ed., 2015.
2. Kelvin T Erickson Dogwood, Programmable Logic Controllers: An Emphasis on Design & Applications, Valley Press, 2nd Ed., 2011.

Reference (s)

1. Mini S Thomas, John D McDonald, Power System SCADA & Smart Grids, CRC Press, Dogwood Valley Press, 2015.
2. W. Bolton. Newnes, Programmable Logic Controllers, Elsevier, 4th Ed., 2006.

21PID013 HVDC Transmission (Elective–V)

4 0 0 4

Course Outcomes

1. Outline different types of HVDC converters and their operation.
2. Summarize the converter control characteristics and Reactive power control
3. Identify the series and parallel operation of HVDC systems and extending to MTDC systems.
4. Demonstrate types and design of different filters and reduction of harmonics
5. Apply different control strategies of converters.
6. Analyze the various types faults and hence protecting the HVDC system.

Unit I

Basic Concepts &Analysis of HVDC Converters

Economics & Terminal equipment of HVDC transmission systems: Types of HVDC Links–Apparatus required for HVDC Systems–Comparison of AC &DC Transmission, Application of DC Transmission System–Planning & Modern trends in D.C. Transmission.

Choice of Converter configuration–analysis of Graetz–characteristics of 6 Pulse &12 Pulse converters –Cases of two 3 phase converters in star –star mode–their performance.

Comparison of HVDC and HVAC

16 Hours

Unit II

Control of Converters & Reactive Power in HVDC systems

Constant current, constant extinction angle and constant ignition angle control Individual phase Control and equidistant firing angle control DC power flow control, Starting and stopping of DC link;

Interaction between HV AC and DC systems–Voltage interaction Harmonic instability problems and DC power modulation Reactive Power Requirements in steady state-Conventional control strategies, sources of reactive power-AC Filters–shunt capacitors-synchronous condensers.

Alternate control strategies

16 Hours

Unit III

MTDC Systems, Converter Fault & Protection

Series parallel and series parallel systems their operation and control.

Converter faults–protection against over current and over voltage in converter station–surge arresters –

Smoothing reactors–DC breakers –Audible noise-space charge field-corona effects on DC lines- Radio Interference.

Effect of Radio waves on Animals & human beings

14 Hours

Unit IV

Harmonics & Filters

Generation of Harmonics –Characteristics harmonics, calculation of AC Harmonics, on- Characteristics, Adverse effects of harmonics–Calculation of voltage & Current harmonics–Effect of Pulse number on harmonics. Types of AC filters, Design of Single tuned filters –Design of High pass filters

Study of active Filters

14 Hours

Total=60 Hours

Textbook (s)

1. K.R.Padiyar,HVDC Power Transmission Systems: Technology and system Interactions,New Age International (P) Limited, and Publishers, 1990.
2. S.Rao, EHVAC and HVDC Transmission Engineering and Practice,Khanna Publishers, 1999.

Reference (s)

1. J. Arrillaga, HVDC Transmission, The Institution of Engineering and Technology, 1998.
2. E. W. Kimbark, Direct Current Transmission, John Wiley & Sons, 1990.
3. E. Uhlmann, Power Transmission by Direct Current, B. S. Publications, 2012.

21PID014Modeling& Simulation of Power Electronic Systems (Elective–V)

4 0 0 4

Course Outcomes

1. Select basic solvers and simulation tools required for Power Electronic Systems.
2. Summarize various solution techniques for time-domain analysis
3. Apply mathematical concepts of modeling to Power Electronic Systems.
4. Rephrase model equations for Electrical systems.
5. Analyze the model equations of Power electronic systems.
6. Simplify analysis & design a system level model of Induction motor drive.

Unit I

Computer Simulation of Power Electronic Converters and Systems

Challenges in computer simulation, simulation process: types of analysis, methods of simulation: circuit-oriented simulators, equation solvers, comparison of circuit oriented simulators and equation solvers, solution techniques for time-domain analysis.

Simulation of three phase converter

16 Hours

Unit II

Differential Equations & Solvers

Linear differential equations, trapezoidal method of integration, nonlinear differential equations, widely used circuit oriented simulators, equation solvers.

Solvers of differential equations

14 Hours

Unit III

Modeling of Power Electronic System Components

DC to DC converters: steady-state equivalent circuit modeling, losses and efficiency, DC transformer model, inclusion of inductor copper loss, construction of equivalent circuit model, mathematical model of a single phase diode-bridge rectifier with a filter capacitor, simulation models for single phase and three phase PWM inverters, DC motor, induction motor

Mathematical model of DC-DC converter

16 Hours

Unit IV

System Level Modeling, Analysis, and Design of Electrical Machines

Phase controlled DC motor drives, chopper-controlled DC motor drive, phase controlled induction motor drive and frequency controlled induction motor drives

Modeling of SRM motor

14 Hours

Total=60 Hours

Textbook (s)

1. Ned Mohan, Tore M. Undeland, William P. Robbins, Power Electronics Converters, Applications, and Design, 3rd Ed., Wiley India Pvt. Ltd, 2010.
2. R.Krishnan, Electric Motor Drives: Modeling, Analysis and Control, 1st Ed., PHI, 2009.

Reference (s)

1. Robert W. Erickson, Dragan Maksimovic, Fundamentals of Power Electronics, 3rd Ed., Springer, 2001.
2. Mahesh B. Patil, V. Ramanarayanan, V. T. Ranganathan, Circuit Simulation for Power Electronics by Alpha Science International Ltd, 2009.

21PID015 Power Quality Issues & Mitigation (Elective–V)

4 0 0 4

Course Outcomes

1. Define the power quality problems
2. List the different methods to mitigate the power quality issues
3. Interpret standard curves to characterize various power system equipment.
4. Identify the right solution to power quality issues
5. Identify the different voltage regulating devices for the Voltage changes
6. Identify different power quality monitoring devices

Unit I

Introduction to Power Quality

Power Quality definition, Voltage Quality, concerns about power quality, The power quality evaluation procedure- General classes of power quality problems, Transients, Long-Duration voltage variations, Short-Duration voltage variations, Voltage Imbalance, waveform distortion, voltage fluctuation, Power frequency variations, CBEMA and ITI curves.

Power quality terms

13 Hours

Unit II

Voltage disturbances and Regulation

Voltage Disturbances-Voltage Sags and Interruptions Sources of sags and interruptions-Estimating Voltage sag performance- Fundamental principles of protection-Solutions at the End-User level-Evaluating the economics of different ride through alternatives-Motor starting sags-Utility system fault clearing issues.

Transient Over Voltages: Sources of transient over voltages-Principles of over voltage protection-Devices for over voltage protection-Utility capacitor_ switching Transients-Utility system Lightning protection- Managing Ferro resonance.

Voltage Regulation-Principles of regulating the voltage-Devices for voltage regulation-Utility voltage regulator application-Capacitors for voltage regulations-End user capacitor application-Regulating utility voltage with distributed resources-Flickers.

Computer tools for transient analysis

17 Hours

Unit III

Harmonics

Harmonic Distortion-Voltage versus current distortion-Harmonic versus Transients-Power system Quantities under non sinusoidal conditions-Harmonic indices-Harmonic sources from commercial loads-Harmonic sources from industrial loads-Locating harmonic sources-System response characteristics- Effects of harmonic distortion- Inter harmonics. Harmonic distortion evaluations-Principles for controlling harmonics-Devices for controlling harmonic distortion

Where to control harmonics and Harmonic study

15 Hours

Unit IV

Power Quality Analysis

Monitoring Considerations, Power Quality Measurement Devices- Harmonic Analyzers, Transient- Disturbance analyzers, Oscilloscopes, True RMS Meters, Power Quality conditioners- DSTATCOM, Dynamic voltage restorer (DVR), unified power quality conditioners, Power Quality Monitoring Standards.

Intelligent Systems for Power quality Management

15 Hours

Total=60 Hours

Textbook (s)

1. Roger C. Dugan, Electrical power systems quality, McGraw- Hill Publications, 3rd Ed., 2012.
2. A. Ghosh and G. Ledwich, Kluwer, Power quality enhancement using custom power devices, Academic Publication, 2002.
3. Angelo Baggini, Handbook of power quality, John Wiley & Sons, 2008

Reference (s)

1. C. Sankaran, Power quality, CRC Press, 2002.
2. Heydt. G. T, Stars, Electric Power Quality Circle Publications, Indiana, 2nd Ed., 1994.
3. Arrillaga. J, Watson, N. R., Chen. S, Power System Quality Assessment, Wiley, New

21PID016 Power Electronic Control of AC Drives (Elective-VI)

4 0 0 4

Course Outcomes

1. Summarize the speed control of electrical drives for day to day applications.
2. Analyze VSI and CSI inverters for induction motors
3. Propose various controlling techniques of ac drive for industrial applications.
4. Design various power electronic converters to control the ac motor.
5. Understand the performance characteristics of inverter fed induction motors to justify their applications
6. Apply various control methods for synchronous motor drive

Unit I

Introduction

Review of steady-state operation of Induction motor, Equivalent circuit analysis, torque-speed characteristics. Voltage Source Inverter Fed Induction motor drives-Scalar control- Voltage fed Inverter control-Open loop volts/Hz control-Speed control with slip, Regulation-Speed control with torque and Flux control.

Current controlled voltage fed Inverter Drive

14 Hours

Unit II

Current Source Inverter Fed Induction motor drives

Current-Fed Inverter control-Independent current and frequency control-Speed and flux control in Current- Fed Inverter drive-Volts/Hz control of Current-Fed Inverter drive

Slip power recovery schemes- Slip-power recovery Drives-Static Kramer drive-Phasor diagram-Torque expression-Speed control of Kramer drive-Static Scherbius drive-Modes of operation.

Efficiency optimization control by flux program

16 Hours

Unit III

Vector control of Induction Motor

Principles of vector control, direct vector control, derivation of indirect vector control, implementation –Block diagram; estimation of flux.

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.

Flux weakening operation

15 Hours

Unit IV

Variable Reluctance Motor Drive

Variable Reluctance motor drives- Torque production in the variable reluctance motor-Drive Characteristics and control principles

PMSM and BLDC Drives-Characteristics of permanent magnet, synchronous machines with permanent magnet, vector control of PMSM- Motor model and control scheme. Modelling of PM brushless dc motor, drive scheme –Three phase full wave Brushless dc motor-Sinusoidal type of Brushless dc motor- current controlled Brushless dc motor Servo drive.

Current control variable reluctance motor servo drive

15 Hours

Total=60 Hours

Textbook (s)

1. John Chiasson, Electric Motor Drives Modeling, Analysis &control, Prentice Hall, 2001.
2. B. K. Bose, Modern Power Electronics and AC Drives, Prentice Hall PTR, 2002.

Reference (s)

1. G.K. Dubey, Power Semiconductor drives, Prentice Hall of India, 1989.
2. M. H. Rashid, Power Electronic Circuits, Devices and Applications, PHI, 3rd Ed., 2009.
3. Bimal K. Bose, Power Electronics and Motor Drives: Advances and Trends, Academic Press, 2006.

21PID017 Flexible AC Transmission Systems (Elective- VI)

4 0 0 4

Course Outcomes

1. Outline the importance and scope of FACTS controllers
2. Classify FACTS controllers
3. Analyze the performance of shunt controllers and reactive power injection
4. Analyze the performance of series controllers and current injection.
5. Analyze combined series and shunt controllers for the given power system network
6. Analyze the performance of UPFC and Interline Power Flow Controller

Unit I

General System Considerations

Transmission Interconnections, flow of power in AC systems, Loading capability, power flow and Dynamic Stability considerations of a transmission interconnections, Relative importance of controllable parameters. Basic types of FACTS Controllers, Benefits from FACTS technology, HVDC versus FACTS. Voltage and current rating – Losses and speed of switching.

Parameter trade–off devices.

15 Hours

Unit II

Shunt Compensation

Static shunt compensators-Objectives of Shunt compensation, Methods of controllable VAR generation-TCR, Mid–point voltage regulation for line segmentation – End of line voltage support to prevent voltage instability –TSC, FC-TCR, TSC-TCR, STATCOM

Improvement of transient stability

15 Hours

Unit III

Series Compensation

Objectives of series compensation, Variable impedance type series compensators -GCSC, TSSC, TCSC and SSSC, Switching converter type series compensators. Three–phase full wave bridge converter– Three–phase current source converter

Comparison of current source converter with voltage source converter

15 Hours

Unit IV

Combined Series and Shunt controllers

Static Voltage Regulators, Objectives of voltage and Phase Angle Regulators, Thyristor Controlled Phase Angle Regulators, Switching converter based Phase Angle Regulators, Unified Power Flow Controller (UPFC) and Interline Power Flow Controller

Application of these controllers on transmission lines

15 Hours

Total=60 Hours

Textbook (s)

1. Narain G. Hingorani and Laszlo Gyugyi, "*Understanding FACTS – Concepts and Technology of Flexible AC Transmission Systems"* IEEPress, Wiley, 2001.
2. K. R. Padiyar, "*FACTS Controllers in Power Transmission & Distribution* ", New Age International (P) Ltd., 2nd edistion,2009.
3. R. Mohan Mathur and Rajiv K. Varma, "*Thyristor Based FACTS Controller for Electrical Transmission Systems",* JohnWiley& sons,2011.

Reference (s)

1. E. Acha, V. G. Agelidis, O. Anaya-Lara, T. J. E. Miller," *Power Electronic Control in Electrical Systems"* Newnes Power Engineering Series, Oxford, 2002.

21PID018 Electrical Drives and Controllers for Electric Vehicles (Elective – VI)

4 0 0 4

Course Outcomes

1. Outline the performance of Electric motor
2. Outline the various control strategies in Electric Vehicle
3. Analyze the performance of Electric vehicle drive system
4. Summarize the characteristics of Induction motor drive in EV application
5. Identify suitable drive for EV applications
6. Analyze the performance of BLDC motor drive in EV application

Unit I

Introduction to Electric Motors and Control Strategies

Types of Motors, Selection and Sizing, RPM and Torque calculations of motor, Motor controllers and component sizing, physical locations, Mechanical and Electrical Connection of motor, Controller overview, switch controller, solid state controller, AC & DC controller.

Electronic controller **15 Hours**

Unit II

Electric Vehicle Drives

Configuration of Electric Vehicles, Performance of Electric Vehicles, Traction motor charterstics, Tractive effort and Transmission requirement, Vehicle performance, Tractive effort in normal driving.

Energy Consumption

15 Hours

Unit III

Electric Propulsion System-I

DC Motor Drive- Introduction, Construction, Principle of operation, Performance charterstics and applications.

Induction Motor Drive- Introduction, Construction, Principle of operation, Performance charterstics and applications.

Various types of starters

16 Hours

Unit IV

Electric Propulsion System-II

BLDC Motor Drive- Introduction, Construction, Principle of operation, Performance charterstics and applications.

PMSM Drive: Introduction, Construction, Principle of operation, Performance charterstics and applications.

Classification properties of PM material

14 Hours

Total=60 Hours

Textbook (s)

1. Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, M. Eshani, CRC Press, 2005.
2. Hybrid Electric Vehicle System Modeling and Control - Wei Liu, General Motors, USA, John Wiley & Sons, Inc., 2017.
3. Husain, I. "Electric and Hybrid Vehicles" Boca Raton, CRC Press, 2010.

Reference (s)

1. Modern Electric Vehicle Technology, C.C. Chan and K.T. Chau, Oxford Science Publication 2001.
2. Electric and Hybrid Vehicles, Tom Denton, Taylor & Francis, 2018.

21AT0001RESEARCH METHODOLOGY and IPR

0 0 0 0

Course Outcomes

1. Understand the various aspects of a research problem
2. Explain the importance of scope and objective of a research problem.
3. Analyze the various components of the format of a good research Proposal.
4. Identify the various concepts of IPR and patenting.
5. Interpret the various scopes of patent rights
6. Outline the various new developments in IPR

UNIT I

RESEARCH PROBLEM AND SCOPE FOR SOLUTION

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

UNIT II

FORMAT

Effective literature studies approaches, analysis, Plagiarism, Research ethics. Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

UNIT III

PROCESS AND DEVELOPMENT

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, patenting under PCT.

UNIT IV

PATENT RIGHTS and IPR

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

Textbook (s)

1. Goddard, Wayne, and Stuart Melville. Research methodology: An introduction. Juta and Company Ltd, 2004.
2. Kumar, Ranjit. Research methodology: A step-by-step guide for beginners. Sage, 2018.

Reference (s)

1. Halbert, “Resist ing Intellectual Property”, Taylor & Francis Ltd ,2007.
2. Mayall, “Industrial Design”, McGraw Hill, 1992.
3. Niebel, “Product Design”, McGraw Hill, 1974.
4. Asimov, “Introduction to Design”, Prent ice Hall, 1962.
5. Robert P. Merges, Peter S. Menell, Mark A. Lemley, “Intellectual Property in New Technological Age”, 2016.
6. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008