PAAVAI ENGINEERING COLLEGE, NAMAKKAL – 637 018
(AUTONOMOUS)
M.E. POWER ELECTRONICS AND DRIVES
REGULATIONS 2015
CURRICULUM

SEMESTER I

Course Code	Course Title	L	T	P	C
PMA 15105	Applied Mathematics for Electrical Engineers	3	2	0	4
PPE 15101	Modeling and analysis of Electrical Machines	3	2	0	4
PPE 15102	Modeling and Simulation of Power Electronic Systems	3	2	0	4
PPE 15103	Analysis of Power Converters	3	0	0	3
PPE 15104	Advanced Power Semiconductor Devices	3	0	0	3
PP* 15E**	Elective – I	3	0	0	3
PPE 15105	Power Electronics Simulation Laboratory	0	0	4	2
PPE 15106	Technical Seminar - I	0	0	2	1

SEMESTER II

Course Code	Course Title	L	T	P	C
PPE 15201	Design of PID Controllers	3	2	0	4
PPE 15202	Solid State AC drives	3	0	0	3
PPE 15203	Solid State DC drives	3	0	0	3
PPE 15204	Embedded Control of Electrical Drives	3	0	0	3
PP* 15E**	Elective – II	3	2	0	4
PP* 15E**	Elective - III	3	0	0	3
PPE 15205	Electric Drives and Control Laboratory	0	0	4	2
PPE 15206	Technical Seminar - II	0	0	2	1

LIST OF ELECTIVES

ELECTIVES – I

Course Code	Course Title	L	T	P	C
PPE 15E01	Analysis of Inverters	3	0	0	3
PPE 15E02	VLSI Design Techniques	3	0	0	3
PPE 15E03	Industrial Robotics	3	0	0	3

ELECTIVES - II

Course Code	Course Title	L	T	P	C
PPS 15E03	Flexible AC Transmission Systems	3	2	0	4
PPE 15E04	Energy Management and Auditing	3	2	0	4
PPE 15E05	Modelling and Analysis of Power Converters	3	2	0	4

ELECTIVES - III

Course Code	Course Title	L	T	P	C
PPS 15E07	Power Quality Analysis	3	0	0	3
PPE 15E06	Power Electronics in Wind and Solar Power Conversion	3	0	0	3
PPE 15E07	MEMS and Microsystems and its Application	3	0	0	3

SEMESTER I

PMA 15105 APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERS 3 2 0 4

COURSE OBJECTIVES

- To develop the ability to apply the concepts of Matrix theory and Linear programming in Electrical Engineering problems.
- To achieve an understanding of the basic concepts of one dimensional random variables and apply in electrical engineering problems.
- To familiarize the students in calculus of variations and solve problems using Fourier transforms associated with engineering applications.

UNIT I MATRIX THEORY 9+3

The Cholesky decomposition – Generalized Eigenvectors, Canonical basis – QR factorization – Least square method – Singular value decomposition.

UNIT II CALCULUS OF VARIATIONS 9+3

Concept of variation and its properties – Euler's equation – Functional dependant on first and higher order derivatives – Functional's dependant on functions of several independent variables – Variational problems with moving boundaries – problems with constraints – Direct methods: Ritz and Kantorovich methods.

UNIT III ONE DIMENSIONAL RANDOM VARIABLES 9+3

Random variables – Probability function – moments – moment generating functions and their properties – Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions – Function of a Random Variable.

UNIT IV LINEAR PROGRAMMING 9+3

Formulation – Graphical solution – Simplex method – Two phase method – Transportation and Assignment Models.

UNIT V FOURIER SERIES 9+3

Fourier Trigonometric series: Periodic function as power signals – Convergence of series – Even and odd function: cosine and sine series – Non-periodic function: Extension to other intervals – Power signals: Exponential Fourier series – Parseval's theorem and power spectrum – Eigen value problems and orthogonal functions – Regular Sturm-Liouville systems – Generalized Fourier series.

TOTAL (L: 45 +T: 15): 60 PERIODS

REFERENCES:

1. Richard Bronson, "Matrix Operation", Schaum's outline series, 2nd Edition, McGraw Hill, (2011).
2. Gupta, A.S., "Calculus of Variations with Applications", Prentice Hall of India Pvt. Ltd., New Delhi, (1997).
3. Oliver C. Ibe, "Fundamentals of Applied Probability and Random Processes", Academic Press, (An imprint of Elsevier), (2010).
4. Taha, H.A., "Operations Research, An introduction", 10th Edition, Pearson education, New Delhi, (2010).
5. Andrews L.C. and Phillips R.L., "Mathematical Techniques for Engineers and Scientists", Prentice Hall of India Pvt.Ltd., New Delhi, (2005).
6. Elsgolts, L., "Differential Equations and the Calculus of Variations", MIR Publishers, Moscow, (1973).
7. O'Neil, P.V., " Advanced Engineering Mathematics", Thomson Asia Pvt. Ltd., Singapore, (2003).
8. Johnson R. A. and Gupta C. B., "Miller & Freund's Probability and Statistics for Engineers", Pearson Education, Asia, 7th Edition, (2007).

WEB LINKS:

1. **http://www.sosmath.com/matrix/matrix.html**
2. **http://tutorial.math.lamar.edu/Classes/CalcI/CalcI.aspx**
3. **http://nptel.ac.in/courses/122104017/28**

PPE 15101 MODELING AND ANALYSIS OF ELECTRICAL MACHINES 3 2 0 4

COURSE OBJECTIVES

- To model the DC machine and analyse its effect on various circuit aspect.
- To analyze the steady state and dynamic state operation of DC machine through mathematical modeling.
- To model the three-phase induction machines and analyzes the steady state and dynamic state operations using transformation theory.
- To impart knowledge on vector controlled induction machines.
- To make the students to equip the knowledge on steady and dynamic state operation of special machines using mathematical models.

UNIT 1 MODELING OF DC MACHINES 9+6

Equivalent circuit and Electromagnetic torque-Electromechanical modeling-Field excitation: separate, shunt, series and compound excitation-commutator action. Effect of armature mmf-Analytical fundamentals: Electric circuit aspects - magnetic circuit aspects - inter poles.

UNIT 2 DYNAMIC MODELING OF INDUCTION MACHINES 9+6

Equivalent circuits - steady state performance equations - Dynamic modeling of induction machines: Real time model of a two phase induction machines, three phase to two phase transformation-Electromagnetic torque-generalized model in arbitrary reference frames-stator reference frames model - rotor reference frames model-synchronously rotating reference frame model.

UNIT 3 PHASE CONTROLLED AND FREQUENCY CONTROLLED INDUCTION MACHINES 9+6

Stator voltage control: Steady state analysis-approximate analysis-slip power recovery scheme: principle of operation-steady state analysis range of slip equivalent circuit-performance-static scherbius drive. Constant Volts/Hz controls implementation-steady state performance-dynamic simulation. PWM Voltages: Generation-machine model-steady state performance.

UNIT 4 VECTOR CONTROLLED INDUCTION MACHINES 9+6

Principle of vector control-direct vector control: flux and torque processor-DVC in stator reference frames with space vector modulation. Indirect vector control scheme: Derivation and implementation. Flux weakening operation: principle-flux weakening in stator flux linkage and rotor flux linkage.

UNIT 5 SPECIAL MACHINES 9+6

Permanent magnet and characteristics-synchronous machines with PMs: Machine configuration-flux density distribution - types of PMSM - Dynamic performance of synchronous machine, comparison of actual and approximate transient torque characteristics, Equal area criteria- simulation of three phase synchronous machine – modeling of PMSM -Variable Reluctance Machines: Basics, analysis--circuit wave forms for torque production - Brushless DC Motor.

TOTAL: 75 PERIODS

COURSE OUTCOMES

Upon the completion of the course, the student will be able to

- understand the necessity of various electrical parameters for mathematical modeling.
- understand the different types of reference frame theories and transformation relationships.
- model and find the electrical machine equivalent circuit parameters and modeling of electrical machines.
- analyze the theory of transformation of three phase variables to two phase variables.
- design simple magnetic circuits by calculating energy, force and torque for single and multi-excited systems.

REFERENCES

1. Charles kingsley, Jr., A.E.Fityzgerald, Stephen D.Umans “Electric Machinery”, Tata McGraw Hill, Sixth Edition, 2002., Reprint, 2010.
2. Miller, T.J.E. “Brushless permanent magnet and reluctance motor drives”, Oxford, 2014.
3. P. S. Bhimbra, “Generalised Theory of Electrical Machines “, Khanna Publications, 2013.
4. R.Krishnan “Electric Motor Drives, “Modeling, Analysis& control”, Pearson Publications, Second Edition, 2003.
5. Bimal K Bose, "Power Electronics and Variable Frequency Drives", IEEE Press, New Jersey, 2006.

WEB LINKS

1. http://www.scribd.com/doc/27104147/Electric-Motor-Drives-Modeling-Analysis
2. file17.neighbourpdf.org/2c5uq-brushless-permanent-magnet-and-reluctance.
3. ledit-lighting.com/download/.../ps-bimbhra-electrical-machinery-solution.

PPE 15102 MODELING AND SIMULATION OF POWER ELECTRONIC SYSTEMS

3 2 0 4

COURSE OBJECTIVES

- To provide the requisite knowledge about the MATLAB and PSPICE models.
- To develop and describe dynamic behavior of basic power electronic circuits using PSPICE.
- To design and analyse the characteristics of power electronic circuits using MATLAB.
- To simulate converter circuits using PSPICE and MATLAB software.
- To understand the performance of various motor drives using simulation tools.

UNIT 1 INTRODUCTION 9+6

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

UNIT 2 PSPICE 9+6

File formats - Description of circuit elements - Circuit description – Output variables - Dot commands - SPICE models of Diode, Thyristor, TRIAC, BJT, Power MOSFET, IGBT and MCT.

UNIT 3 MATLAB AND SIMULINK 9+6

Toolboxes of MATLAB - Programming and file processing in MATLAB – Model definition and model analysis using SIMULINK - S-Functions - Converting S-Functions to blocks.

UNIT 4 SIMULATION USING PSPICE, MATLAB AND SIMULINK 9+6

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

UNIT 5 SIMULATION OF DRIVES 9+6

Simulation of speed control schemes for DC motors – Rectifier fed DC motors – Chopper fed DC motors – VSI and CSI fed AC motors – PWM Inverter – DC link inverter.

TOTAL: 75 PERIODS

COURSE OUTCOMES

Upon completion of the course, the student will be able to

- understand the fundamentals of simulation software tools.

- design power electronic circuits using PSPICE and analyse their behaviour.
- model and simulate circuits using MATLAB functional blocks.
- demonstrate circuit simulation and using PSPICE and MATLAB.
- analyse the performance of various motor drive under simulation.

REFERENCES

1. Muhammad H .Rashid,"Spice for Power Electronics and Electric Power ", CRC Press, Taylor and Francies Group, 2006.
2. Ned Mohan, "Power Electronics: Computer Simulation Analysis and Education using PSPICE", Minnesota Power Electronics Research and Education, USA, 2002.
3. Bimal K Bose, "Power Electronics and Variable Frequency Drives", IEEE Press, New Jersey, 2006.
4. M.B.Patil “Simulation of Power Electronics Circuits“ Narosa Publishing house, 2009.
5. B. P. Singh and Rekha Singh, “Electronic Devices and Circuit”, Pearson Education, 2013.

WEB LINKS

1. www.125books.com/move-other-bk.php?file=125BOOKS.COM...pdf
2. exactdownload.com/download.php?...Power%20Electronics%20and%20.
3. www.debtbooks.org/d8ij3_ebooks-simulation-of-power-electronic-circuits

PPE 15103 ANALYSIS OF POWER CONVERTERS 3 0 0 3

COURSE OBJECTIVES

- To understand the circuit concepts and operation of single phase power converters.
- To gain knowledge on various types of three-phase converters and their performance.
- To analyze and comprehend the various operating modes of different configurations of DC-DC power converters.
- To derive the design criteria for the design of AC voltage power converters.
- To impart knowledge on various applications of converters.

UNIT 1 SINGLE PHASE AC-DC CONVERTER 12

Static Characteristics of power diode, SCR and GTO, half controlled and fully controlled converters with R-L, R-L-E loads and freewheeling diodes – continuous and discontinuous modes of operation - inverter operation – Dual converter - Sequence control of converters – performance parameters: harmonics, ripple, distortion, power factor – effect of source impedance and overlap-reactive power and power balance in converter circuits.

UNIT 2 THREE PHASE AC-DC CONVERTER 9

Semi and fully controlled converter with R, R-L, R-L-E - loads and freewheeling diodes – inverter operation and its limit – dual converter– performance parameters – effect of source impedance and over lap – 12 pulse converter.

UNIT 3 DC-DC CONVERTERS 9

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

UNIT 4 AC CONTROLLERS 9

Static Characteristics of TRIAC- Principle of phase control: single phase and three phase controllers – various configurations – analysis with R and R-L loads. Principle of operation of cycloconverter – Single phase and three phase cycloconverters – power factor Control-Forced commutated cycloconverters – Applications.

UNIT 5 APPLICATIONS OF CONVERTERS 6

Residential Applications- Air Conditioning- Induction Cooking- Industrial Applications- Induction heating- Integral Half cycle controllers- Electric Utility Applications- HVDC

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon the completion of the course, students will be able to

- use the basic concepts for steady state operation of single and three phase AC-DC converters.
- analyse the performance parameters of single and three phase AC-DC converters.
- differentiate the operating modes of various configurations of power converters.
- analyse and control the operation of converters under various load conditions.
- design power converters for industrial and residential applications.

REFERENCES

1. Ned Mohan, Undeland and Robbin, "Power Electronics: converters, Application and design" John Wiley and sons. Inc, Newyork, 2009.
2. Rashid M.H., "Power Electronics Circuits, Devices and Applications ", Prentice Hall India, New Delhi, 2004.
3. Vedam Subrahmanyam., "Power Electronics: Devices, Converters, Applications", New Age International Pvt. Ltd- 2006. .
4. P.C Sen.," Modern Power Electronics ", Wheeler publishing Co, First Edition, New Delhi-2005.
5. P.S.Bimbra., "Power Electronics", Khanna Publishers, Eleventh Edition, 2003.

WEB LINKS

1. https://cld.pt/.../download/.../Power%20Electronics%20Handbook%203r.
2. https://myarchive4u.wordpress.com/.../power-electronics-circuitsdevices.
3. 7see.blogspot.com/2015/06/power-electronics-by-ps-bimbra-free.html

PPE 15104 ADVANCED POWER SEMICONDUCTOR DEVICES 3 0 0 3

COURSE OBJECTIVES

- To make understand the power semiconductor device structures and characteristics.
- To study basic principle and operation of thyristors.
- To understand the static and dynamic characteristics of current controlled power semiconductor devices.
- To study basic principle and operation of voltage controlled devices.
- To learn the basic principles and operation of firing and protecting circuits.

UNIT 1 INTRODUCTION 9

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

UNIT 2 THYRISTORS 9

Thyristors – Physical and electrical principle underlying operating mode, Two transistor analogy – concept of latching- Gate and switching characteristics- commutation of thyristors - converter grade and inverter grade; series and parallel operation- Models of Thyristors.

UNIT 3 CURRENT CONTROLLED DEVICES 9

Power BJT's – Construction, static characteristics, switching characteristics; Negative temperature co-efficient and secondary breakdown; Power Darlington - comparison of BJT and Thyristor – steady state and dynamic models of BJT.

UNIT 4 VOLTAGE CONTROLLED DEVICES 9

Power MOSFETs and IGBTs – Principle of voltage controlled devices, construction, types, static and switching characteristics, steady state and dynamic models of MOSFET and IGBTs - Basics of GTO, MCT, RCT and IGCT-Intelligent Power Modules-Selection of Power Semiconductor Devices for typical Applications.

UNIT 5 FIRING AND PROTECTION CIRCUITS 9

Necessity of isolation, pulse transformer, opto-coupler – Gate drives circuit: SCR – R, RC, UJT, MOSFET, IGBTs and base driving for power BJT. - Over voltage, over current and gate protections; Design of snubbers. Heat transfer – conduction, convection and radiation, Electrical analogy of

thermal components- Thermal resistance and impedance, Guidance for heat sink selection –Mounting types.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, students will be able to

- know the various power semiconductor devices and its characteristics.
- use the thyristor models for industrial applications .
- understand the characteristics of current controlled devices.
- know the basic principle and operation of voltage controlled devices.
- realize the operation of firing and protection circuits.

REFERENCES

1. Rashid M.H., "Power Electronics Circuits, Devices and Applications ", Prentice Hall of India, Third Edition, NewDelhi, 2004.
2. MD Singh and K.B Khanchandani, "Power Electronics", Tata McGraw Hill, 2001.
3. NedMohan, Undeland and Riobbins, "Power Electronics – Concepts, applications and Design", John Wiley and Sons,Singapore, 2003.
4. Vedam Subramaniyam, "Power Electronics – Devices, Converters and Applications ", New Age International private Ltd., 2nd Edition, 2006.
5. P.C.Sen, Modern Power Electronics, S. Chand Limited, 2005.

WEB LINKS

1. https://cld.pt/.../download/.../Power%20Electronics%20Handbook%203r.
2. https://myarchive4u.wordpress.com/.../power-electronics-circuitsdevices-.
3. century61clinic.thecoolcatalog.com/.../modern-power-electronics_nilkke.

PPE 15105 POWER ELECTRONICS SIMULATION LABORATORY 0 0 4 2

COURSE OBJECTIVES

- To provide hands on experience on various techniques and software packages for the simulation of power electronic components and circuits.

LIST OF EXPERIMENTS

1. Modeling of Silicon Controlled Rectifier/ MOSFET/IGBT/ BJT.
2. Simulation of Single phase Semi converter with
   a) R Load, b) RL load, c) RLE (Motor) Load.
3. Simulation of Single phase fully controlled converter.
   a) R Load, b) RL load, c) RLE (Motor) Load.
4. Simulation of Single phase Dual converter.
5. Simulation of Three phase semi converter.
6. Simulation of Three phase fully controlled converter.
7. Simulation of Single phase full bridge Inverter.
8. Simulation of Three phase full bridge inverter.
   a) 180 degree mode operation, b) 120 degree mode operation
9. Simulation of PWM inverters.
   a) Sinusoidal PWM, b) Square PWM.
10. Simulation of Three phase AC Voltage Controller.
    a) Lamp load, b) Motor load.

COURSE OUTCOMES

Upon the completion of the course, students will be able to

- simulate and analyze various DC-DC converters , single and three phase inverters and voltage controllers.

TOTAL: 45 PERIODS

PPE 15106 TECHNICAL SEMINAR - I 0 0 2 1

COURSE OBJECTIVES

- To help students to acquire communication and presentational skills and their application in social communication.
- To strengthen their prospects of success in technical presentation

In this course, every student has to present at least two technical papers on recent advancements in engineering/technology referring journal papers and will be evaluated by the course instructor. During the seminar session, each student is expected to present a topic, for duration of about 15 to 20 minutes which will be followed by a discussion for 5 minutes. Each student is responsible for selecting a suitable topic that has not been presented previously. Every student is expected to participate actively in the ensuing class discussion by asking questions and providing constructive criticism.

COURSE OUTCOMES

Upon the completion of the course, students will be able to

- communicate effectively.
- learn skills essential for becoming successful student researchers.

TOTAL: 30 PERIODS

SEMESTER II

PPE 15201 DESIGN OF PID CONTROLLERS 3 2 0 4

COURSE OBJECTIVES

- To study the various structures of PID controllers and its performance characteristics.
- To understand the implementation techniques of PID controllers.
- To design the system using conventional PID controllers.
- To introduce the knowledge on design a control system with conventional tuning PID controllers.
- To impart the knowledge on the advanced tuning methods.

UNIT 1 INTRODUCTION TO CONTROLLERS 9+6

Introduction of controllers – feedback, feed forward and cascade controllers - PID control-modification of PID algorithm - Parallel PID86Controllers, Conversion to Time constant PID Forms, Series PID Controllers, Simple PID Tuning

UNIT 2 PID CONTROLLER IMPLEMENTATION ISSUES 9+6

Bandwidth-Limited Derivative Control – Proportional Kick – Derivative Kick – Integral Anti-Windup Circuits - Reverse-Acting Controller: Digital Implementation – Operational aspects – Commercial controllers.

UNIT 3 CONTROLLER DESIGN 9+6

Control structures - Time and frequency domain performance measures - Ziegler-Nichols' and Related Methods - Loop Shaping - Optimization Methods - Pole Placement - Dominant Pole Design - Design for Disturbance Rejection.

UNIT 4 CONVENTIONAL TUNING METHODS OF PID CONTROLLER 9+6

A spectrum of Tools – Step Response methods – Frequency response methods – Phase locked loop methods - Complete process knowledge – Assessment of Performance

UNIT 5 FUZZY LOGIC AND GENETIC ALGORITHM METHODS IN PID TUNING 9+6

Fuzzy PID Supervision for an Automotive Application: Design and Implementation, Multi-Objective Optimised Genetic Algorithm Fuzzy PID Control, Application of Fuzzy PID Control in Robotics.

TOTAL: 75 PERIODS

COURSE OUTCOMES

Upon the completion of the course, students will be able to

- implement the concept of PID controller structures and performance specifications.
- identify and resolve the practical implementation issues of PID controller.
- develop controller using optimization methods.
- design a control system with conventional tuning methods of PID controllers.
- design the advanced PID tuning technology and its applications.

REFERENCES

1. Johnson and H. Moradi, "PID Control: New Identifications and Design Methods" Springer - Verlag, 2005.
2. Štefan Kozák, M. Huba,"Control Systems Design",-First Edition, 2004.
3. Cheng-Ching Yu, "Auto tuning of PID Controllers; A Relay Feedback 87Approach" Springer, 2nd Edition, 2006.
4. Antonio Visioli, "Practical PID Control" Springer-Verlag London Limited, 2006.
5. Guillermo J. Silva, Aniruddha Datta & S.R Bhattacharyya, "PID Controllers for Time-Delay Systems" Printed in the United States of America, 2005.

WEB LINKS

1. http://manual80.bunchebooks.org/1yhnsd_pid-control-new-identification-and-design-methods.pdf
2. www.wagonbooks.org/.../1o11l9_control-systems-design-2003-conferen.
3. www.cse.zju.edu.cn/gckzgc/inc/download.php?id=44&mod=gckzgc

PPE 15202 SOLID STATE AC DRIVES 3 0 0 3

COURSE OBJECTIVES

- To impart knowledge on operation and analysis of Induction Motors.
- To analyze the operation VSI and CSI fed induction motor drives.
- To learn the speed control of induction motor drive from the rotor side.
- To study the field oriented control of induction machines.
- To equip the students the controlling methods of synchronous motor drives.

UNIT 1 INTRODUCTION TO INDUCTION MOTORS 9

Steady state performance equations – Rotating magnetic field – torque production, Equivalent circuit– Variable voltage, constant frequency operation – Variable frequency operation, constant Volt/Hz operation. Drive operating regions, variable stator current operation.

UNIT 2 VSI AND CSI FED INDUCTION MOTOR CONTROL 9

AC voltage controller circuit – four quadrant control and closed loop operation – loss minimation -six step inverter voltage control - closed loop variable frequency PWM inverter with dynamic braking , regenerative braking, loss minimation - CSI fed IM variable frequency drives comparison.

UNIT 3 ROTOR CONTROLLED INDUCTION MOTOR DRIVES 9

Static rotor resistance control - injection of voltage in the rotor circuit - conventional rotor resistance control – Double fed Machine Speed control - static scherbius drives; modes of operation, modified scherbius drive for VSCF power generation - power factor considerations – Static Kramer drive; speed control of Kramer drive - modified Kramer drives.

UNIT 4 FIELD ORIENTED CONTROL 9

Field oriented control of induction machines – Theory – DC drive analogy – Direct and Indirect methods – Flux vector estimation - Direct torque control of Induction Machines – Torque expression with stator and rotor fluxes, DTC control strategy-Adaptive control- Self Commissioning of Drive.

UNIT 5 SYNCHRONOUS MOTOR DRIVES 9

Wound field cylindrical rotor motor – Equivalent circuits – performance equations of operation from a voltage source – Power factor control and V curves – starting and braking, self-control – Load commutated Synchronous motor drives –Sensorless Control- Brush and Brushless excitation.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon the completion of the course, students will be able to

- know the concept of various operating regions of the induction motor drives.
- understand the operation of VSI & CSI fed induction motor control.
- design and analyze the operation of the speed control of induction motor drive from the rotor side.
- obtain various methods of various field oriented control strategies.
- realize the control methods of synchronous machine drives.

REFERENCES

1. S.Sivanagaraju, M.Balasubba Reddy and A.Mallikariuna Prased "Power Semiconductor Drives", PHI Learning Pvt Ltd, 2009.
2. Rashid M.H., "Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Third Edition, New Delhi, 2004.
3. R.Krishnan, "Electric Motor Drives – Modeling, Analysis and Control", Prentice-Hall of India Pvt. Ltd., New Delhi, 2003.
4. Power Converters and AC Electrical Drives with Linear Neural Networks" Narosa Publishing House, 2002.
5. Bimal K Bose, "Modern Power Electronics and AC Drives", Pearson Education Asia, 2002.

WEB LINKS

1. https://www.scribd.com/.../Electric-Motor-Drives-Modeling-Analysis.
2. https://myarchive4u.wordpress.com/.../power-electronics-circuitsdevices.
3. century61clinic.thecoolcatalog.com/.../modern-power-electronics_nilkke.

PPE 15203 SOLID STATE DC DRIVES 3 0 0 3

COURSE OBJECTIVES

- To understand steady state operation and transient dynamics of a motor load system.
- To analyze the phase control and fundamental relations of types of DC motor drives.
- To study and analyze the operation of the various chopper fed DC drive.
- To understand the current and speed controllers for a closed loop solid state DC motor drives.
- To know the digital control techniques of various D.C Drives.

UNIT 1 DC MOTORS FUNDAMENTALS AND MECHANICAL SYSTEMS 9

DC motor- Types, induced emf, speed-torque relations; Speed control – Armature and field speed control; Ward Leonard control – Constant torque and constant horse power 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 2 CONVERTER CONTROL 9

Principle of phase control – Fundamental relations; Analysis of series and separately excited DC motor with single-phase and three-phase converters – waveforms, performance parameters, performance characteristics. Continuous and discontinuous armature current operations; Current ripple and its effect on performance; Operation with freewheeling diode; Implementation of braking schemes; Drive employing dual converter; Applications.

UNIT 3 CHOPPER CONTROL 9

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

UNIT 4 CLOSED LOOP CONTROL 9

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

UNIT 5 DIGITAL CONTROL OF D.C DRIVE 9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon the completion of the course, the student will be able to

- know the basic concepts of steady state and dynamics behaviour a motor.
- demonstrate the different current conduction mode in converter fed DC drives.
- differentiate the operations of the various types of chopper.
- model and analyze the current and speed controllers for closed loop solid state DC motor drives.
- implement the algorithms for digital control of D.C Drives.

REFERENCES

1. Gobal K.Dubey, “Fundamentals of Electrical Drives”, Narosal Publishing House,New Delhi, 2009.
2. R.Krishnan, “Electric Motor Drives–Modeling, Analysis and Control”, Prentice-Hall of India Pvt. Ltd., New Delhi, 2007.
3. Vedam Subramanyam, “Electric Drives – Concepts and Applications”, Tata McGraw Hill, Second Edition, 2010.
4. P.C Sen “Thyristor DC Drives”, John wiley and sons, New York, 1981.
5. Buxbaum, A.Schierau, K.and Staughen, "A Design of control System for d.c Drives ", Springer-Verlag, berlin, 1990.

WEB LINKS

1. https://www.scribd.com/.../Electric-Motor-Drives-Modeling-Analysis.
2. http://www.scribd.com/doc/101099222/A-Guide-to-Electric-Drives-and-DC-Motor-Control#scribd.
3. www.bowpdf.org/1zu5cu_pdf-book-control-design-techniques-in-power.

PPE 15204 EMBEDDED CONTROL OF ELECTRICAL DRIVES 3 0 0 3

COURSE OBJECTIVES

- To make the students to equip the fundamentals of microcontrollers.
- To familiarize about the I/O interfacing techniques of microcontrollers.
- To impart knowledge on the fundamentals of PIC controllers.
- To educate I/O interfacing techniques of PIC controllers.
- To learn about the various application of embedded control drives.

UNIT 1 MC68HC11 MICROCONTROLLER 9

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

UNIT 2 PERIPHERALS OF MC68HC11 9

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

UNIT 3 PIC 16C7X MICROCONTROLLER 9

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

UNIT 4 PERIPHERAL OF PIC 16C7X MICROCONTROLLER 9

Architecture, memory organization - addressing modes. Instruction set programming in Assembly & C- I/O port, Data Conversion Timers - interrupts - I/O ports - I2C bus for peripheral chip access - A/D converter – VART

UNIT 5 EMBEDDED CONTROL OF DRIVES 9

Generation of PWM pulses using embedded processors IC - control of DC drives - V/F control using PIC microcontroller - Vector control using embedded processors - Stepper motor control using PIC microcontroller - Brush less D.C. motor control using embedded processors.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon the completion of the course, the students will be able to

- understand the basics of MC68HC11 controller.
- use MC68HC11 processors to interface different I/O units.
- use the basic knowledge of PIC controllers for drive applications.

- demonstrate the PIC controllers to interface different I/O units.
- implement the controllers for various electrical drive applications.

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2. Michael Khevi, “The M68HC11 Microcontroller Applications in Control, Instrumentation and Communication”, Prentice Hall, 1997.
3. John B. Peatman, “Design with Microcontrollers”, McGraw-Hill, 1988.
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PPE 15205 ELECTRIC DRIVES AND CONTROL LABORATORY 0 0 4 2

COURSE OBJECTIVES

- To analyze, design and implement different power circuits and controllers for different motor drives and electrical machines.

LIST OF EXPERIEMENTS

1. Micro controller based speed control of Stepper motor.
2. DSP based speed control of BLDC motor.
3. DSP based speed control of SRM motor.
4. Condition monitoring of three-phase induction motor under fault conditions.
5. Chopper Fed DC Drive.
6. DSP controlled AC drive.
7. FPGA controlled AC drive
8. Analysis of Dual Converter Fed DC Motor Drive.
9. Analysis of Vector Controlled Induction Motor Drive.
10. V/f control of three-phase induction motor.

COURSE OUTCOMES

Upon the completion of the course, students will be able to acquire requisite knowledge necessary to appreciate the dynamic control methods for various motor drives using different PED configurations.

TOTAL: 45 PERIODS

PPE 15206 TECHNICAL SEMINAR - II 0 0 2 1

COURSE OBJECTIVES

- To help students to acquire communication and presentational skills and their application in social communication.
- To enrich their knowledge on recent technical topics.

In this course, every student has to present at least two technical papers on recent advancements in engineering/technology referring journal papers and will be evaluated by the course instructor. During the seminar session, each student is expected to present a topic, for duration of about 15 to 20 minutes which will be followed by a discussion for 5 minutes. Each student is responsible for selecting a suitable topic that has not been presented previously. Every student is expected to participate actively in the ensuing class discussion by asking questions and providing constructive criticism.

COURSE OUTCOMES

Upon the completion of the course, students will be able to

- prepare quality and focused presentation and communicate effectively.

TOTAL: 30 PERIODS

LIST OF ELECTIVES

PPE 15E01 ANALYSIS OF INVERTERS 3 0 0 3

COURSE OBJECTIVES

- To provide the electrical circuit concepts behind the different working modes of single phase inverters.
- To brief the different working modes of three phase inverters and various switching techniques.
- To make the students to gain knowledge on design and development of current source inverters.
- To analyse and comprehend the various operating modes of different configurations of power converters.
- To familiarize the concepts of various resonant inverter techniques and its application.

UNIT 1 SINGLE PHASE INVERTERS 12

Introduction to self commutated switches : MOSFET and IGBT - Principle of operation of half and full bridge inverters – Performance parameters – Voltage control of single phase inverters using various PWM techniques – various harmonic elimination techniques – forced commutated Thyristor inverters.

UNIT 2 THREE PHASE VOLTAGE SOURCE INVERTERS 9

180 degree and 120 degree conduction mode inverters with star and delta connected loads – voltage control of three phase inverters: single, multi pulse, sinusoidal, space vector modulation techniques.

UNIT 3 CURRENT SOURCE INVERTERS 9

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

UNIT 4 MULTILEVEL INVERTERS 9

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

UNIT 5 RESONANT INVERTERS 6

Series and parallel resonant inverters - voltage control of resonant inverters – Class E resonant inverter – resonant DC – link inverters- advancements in inverter technology for industrial applications. **TOTAL: 45 PERIODS**

COURSE OUTCOMES

Upon the completion of the course, students will be able to

- understand the various circuit concepts of single phase inverters.
- analyse the working of three phase inverters with modulation techniques.
- design and develop current source inverters.
- derive the design criteria and analyse the various operating modes of different configurations of power converters.
- design inverters for various power applications.

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1. Rashid M.H., “Power Electronics Circuits, Devices and Applications ", Prentice Hall India, New Delhi, 2011.
2. Bimal K.Bose., “Modern Power Electronics and AC Drives”, Pearson Education, 2009.
3. Ned Mohan, Undeland and Robbin, “Power Electronics: converters, Application and design” John Wiley and sons. Inc, Newyork, 2009.
4. P.C. Sen, “Modern Power Electronics”, S. Chand Limited, New Delhi, 2008.
5. P.S.Bimbra, “Power Electronics”, Khanna Publishers, 2005.
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PPE 15E02 VLSI DESIGN TECHNIQUES 3 0 0 3

COURSE OBJECTIVES

- To learn the significance of CMOS technology and fabrication process.
- To understand the importance and architectural features of programmable logic devices.
- To introduce the ASIC construction, design algorithms and basic analog VLSI design techniques.
- To familiarize the students in VHDL programming.
- To study the logic synthesis and simulation of digital system using VHDL and Verilog HDL.

UNIT I CMOS DESIGN 9

Overview of digital VLSI design Methodologies- Logic design with CMOS-transmission gate circuits - Pass Transistor - Clocked CMOS-dynamic CMOS circuits, Bi-CMOS circuits- Layout diagram, Stick diagram-IC fabrications – Trends in IC technology.

UNIT II PROGRAMABLE LOGIC DEVICES 12

Programming Techniques-Anti fuse-SRAM-EPROM and EEPROM technology – Re- Programmable Devices Architecture- Function blocks, I/O blocks, Interconnects, Xilinx- XC9500,Cool Runner - XC-4000,XC5200, SPARTAN, Virtex - Altera MAX 7000-Flex 10KStratix.

UNIT III BASIC CONSTRUCTION, FLOOR PLANNING, PLACEMENT AND ROUTING 6

System partition – FPGA partitioning – Partitioning methods- floor planning – placement physical design flow – global routing – detailed routing – special routing- circuit extraction –DRC.

UNIT IV VHDL PROGRAMMING 6

RTL Design – Restructured level Design -combinational logic – Types – Operators – Packages – Sequential circuit – Sub programs – Test benches. (Examples: address, counters, flip-flops, FSM, Multiplexers / Demultiplexers).

UNIT V LOGIC SYNTHESIS AND SIMULATION 12

Overview of digital design with Verilog HDL- hierarchical modeling concepts- modules and port definitions- gate level modeling- data flow modeling- behavioral modeling- task & functions- Verilog and logic synthesis-simulation-Design examples- Ripple carry Adders- Carry Look ahead adders- Multiplier- ALU- Shift Registers, Multiplexer- Comparator- Test Bench

TOTAL: 45 PERIODS

COURSE OUTCOMES

By the end of this course, the student will be able to

- understand the basic concepts of CMOS circuits
- acquire knowledge on architectural features of programmable logic devices.
- realize basic analog VLSI design techniques.
- apply and use VHDL Programming for various logic circuits.
- design and simulate the basic analog and digital ciruits using Verilog HDL.

REFERENCES

1. E. Eshranghian, D.A. Pucknell and S. Eshraghian, “Essentials of VLSI circuits and systems”, PHI, 2010.
2. Neil H.E. Weste, David Harris and Ayan Banerjee, “CMOS VLSI Design, A circuits and Systems Perspective”, 2010.
3. W. Wolf, “Modern VLSI Design”, Fourth Edition, Pearson, 2009.
4. S.M. Sze, “VLSI Technology”, Second Edition, Mc Graw Hill, Deluxe Edition, 2010.
5. Douglas Perry, ‘VHDL Programming By Example’, Tata Mc Graw Hill, Third Edition, 2007.

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PPE 15E03 INDUSTRIAL ROBOTICS 3 0 0 3

COURSE OBJECTIVES

- To give introduction about the fundamentals of robotics and its application.
- To acquire knowledge about the principles and operation of robot drive mechanisms, mechanical transmission method.
- To familiarize the characteristics of various sensors.
- To obtain the knowledge of robot vision systems and image processing.
- To build and understand the building blocks of automation, controllers and its architecture.

UNIT 1 INTRODUCTION 6

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

UNIT 2 ROBOT DRIVES AND POWER TRANSMISSION SYSTEMS 9

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

UNIT 3 SENSORS 9

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

UNIT 4 VISION SYSTEMS 9

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

UNIT 5 PLC AND AUTOMATIONS 12

Building blocks of automation, Controllers – PLC- Role of PLC in FA - Architecture of PLC - Advantages - Types of PLC - Types of Programming - Simple process control programs using Relay

Ladder Logic and Boolean logic methods - PLC arithmetic functions Flexible Manufacturing Systems concept - Automatic feeding lines, ASRS, transfer lines, automatic inspection - Computer Integrated Manufacture - CNC, intelligent automation. Industrial networking, bus standards, HMI Systems, DCS and SCADA, Wireless controls.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon the completion of the course, the students will be able to

- understand the fundamentals and terminologies of robotics.
- acquire the knowledge of various robotic equipments and motion convertors.
- understand the operation of various sensors
- describe the Robot vision systems and image processing.
- understand and design Building blocks of PLC automation and various control techniques

REFERENCES

1. Groover, Weiss, Nagel.,"Industrial Robotics", McGraw Hill International, 2nd edition, 2012.
2. Klafter, Chmielewski and Negin .,"Robotic Engineering - An Integrated approach", Klafter, Chmielewski and Negin, PHI, 1st edition, 2009.
3. S. R. Deb and S. Deb, "Robotics Technology and Flexible Automation", Tata McGraw Hill Education Pvt. Ltd, 2010.
4. John J.Craig , "Introduction to Robotics", Pearson, 2009.
5. Mikell P. Groover et. al., "Industrial Robots - Technology, Programming and Applications", McGraw Hill, New York, 2008

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PPS 15E03 FLEXIBLE AC TRANSMISSION SYSTEMS 3 2 0 4

COURSE OBJECTIVES

- To emphasis the need of FACTS controllers.
- To learn the characteristics, applications and modelling of SVC controllers.
- To understand the characteristics, applications and modelling of TCSC controllers.
- To know about the emerging trends of FACTS controller.
- To analyze the interaction of different FACTS controllers and perform control coordination.

UNIT 1 INTRODUCTION 9+6

Reactive power control in electrical power transmission lines –Uncompensated transmission line - series compensation – Basic concepts of Static Var Compensator (SVC)–Thyristor Switched Series capacitor (TCSC) – Unified power flow controller (UPFC).

UNIT 2 STATIC VAR COMPENSATOR (SVC) AND APPLICATIONS 9+6

Voltage control by SVC – Advantages of slope in dynamic characteristics – Influence of SVC on system voltage – Design of SVC voltage regulator –Modelling of svc for power flow and transient stability – Applications: Enhancement of transient stability – Steady state power transfer – Enhancement of power system damping – Prevention of voltage instability.

UNIT 3 THYRISTOR CONTROLLED SERIES CAPACITOR (TCSC) AND APPLICATIONS 9+6

Operation of the TCSC – Different modes of operation – Modelling of TCSC – Variable reactance model – Modelling for Power Flow and stability studies. Applications: Improvement of the system stability limit – Enhancement of system damping-SSR Mitigation.

UNIT 4 VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS 9+6

Static Synchronous Compensator (STATCOM) – Principle of operation – V-I Characteristics. Applications: Steady state power transfer-Enhancement of transient stability - Prevention of voltage instability. SSSC-operation of SSSC and the control of power flow –Modelling of SSSC in load flow and transient stability studies. Applications: SSR Mitigation-UPFC and IPFC

UNIT 5 CO-ORDINATION OF FACTS CONTROLLERS 9+6

Controller interactions – SVC – SVC interaction – Co-ordination of multiple controllers using linear control techniques – Control coordination using genetic algorithms.

TOTAL: 75 PERIODS

COURSE OUTCOMES

Upon the completion of the course, students will be able to

- understand the need for FACTS controllers.
- learn the characteristics, applications and modeling of SVC controllers.
- learn the characteristics, applications and modeling of TCSC controllers.
- update knowledge on the merging trends of FACTS controllers.
- analyze the interaction of different FACTS controller and perform control coordination.

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1. R.MohanMathur, Rajiv K.Varma, "Thyristor – Based Facts Controllers for Electrical Transmission Systems", IEEE press and John Wiley & Sons, Inc., 2002.
2. Narain G. Hingorani, "Understanding FACTS -Concepts and Technology of Flexible AC Transmission Systems", Standard Publishers Distributors, Delhi- 110 006, 2000.
3. K.R.Padiyar," FACTS Controllers in Power Transmission and Distribution", New Age International (P) Limited, Publishers, New Delhi, 2008.
4. A.T.John, "Flexible A.C. Transmission Systems", Institution of Electrical and Electronic Engineers, IEEE, 1999.
5. Xiao – Ping Zang, Christian Rehtanz and Bikash Pal, "Flexible AC Transmission System: Modelling and Control" Springer, 2012.

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PPE 15E04 ENERGY MANAGEMENT AND AUDITING 3 2 0 4

COURSE OBJECTIVES

- To emphasis the need for energy management and energy audit process.
- To study the concepts of economic analysis and load management.
- To brief about the energy management on various electrical equipments.
- To familiarize with the various measuring techniques.
- To illustrate the concept of lighting systems and cogeneration.

UNIT I INTRODUCTION 9+6

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

UNIT II ENERGY COST AND LOAD MANAGEMENT 9+6

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

UNIT III ENERGY MANAGEMENT FOR MOTORS, SYSTEMS, AND ELECTRICAL EQUIPMENT 9+6

Systems and equipment- Electric motors-Transformers and reactors-Capacitors and synchronous machines

UNIT IV METERING FOR ENERGY MANAGEMENT 9+6

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

UNIT V LIGHTING SYSTEMS & COGENERATION 9+6

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

TOTAL: 75 PERIODS

COURSE OUTCOMES

Upon the completion of the course, the students will be able to

- realize the need for energy management and auditing.
- learn about economic analysis and load management.
- use energy management for various electric equipments.
- understand the various types of measuring devices.
- obtain the solution of optimize lighting energy and feasibility of cogeneration.

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1. Reay D.A, "Industrial Energy Conservation", 1stedition, Pergamon Press, 1977.
2. IEEE Recommended Practice for "Energy Management in Industrial and Commercial Facilities", IEEE, 196.
3. Amit K. Tyagi, "Handbook on Energy Audits and Management", TERI, 2003.
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PPE 15E05 MODELLING AND ANALYSIS OF POWER CONVERTERS 3 2 0 4

COURSE OBJECTIVES

- To make the students to understand the modelling of AC equivalent circuits.
- To brief and analyze the transfer function of converters.
- To impart knowledge about the design of filters and its effects on converters.
- To provide adequate information about the non-linearity in DC converters
- To describe the non-linear operations in power electronic systems.

UNIT I AC EQUIVALENT CIRCUIT MODELING 9+6

Basic AC modelling approach- State-space averaging- Circuit averaging and averaged switch modelling- Canonical circuit model- Modeling the pulse-width modulator – Problems.

UNIT II CONVERTER TRANSFER FUNCTIONS 9+6

Analysis of converter transfer functions- Graphical construction of impedances and transfer functions- Graphical construction of converter transfer functions- Measurement of AC transfer functions and impedances – Problems.

UNIT III INPUT FILTER DESIGN 9+6

Introduction- Effect of an input filter on converter transfer Functions- Buck converter example- Design of a damped input filter – Problems

UNIT IV NON-LINEAR PHENOMENA IN DC-DC CONVERTERS 9+6

Basics of bifurcation and chaos theory - Border collision bifurcations in the current mode controlled boost converter - Bifurcations and chaos in the latched voltage controlled buck converter - Routes to chaos in the voltage controlled buck converter without latch Saddle-node and Neimark bifurcations in PWM DC-DC converters -Nonlinear analysis of the operation in discontinuous conduction mode - Nonlinear phenomena in the Cuk converter

UNIT V NON-LINEAR PHENOMENA IN OTHER POWER ELECTRONICS CIRCUITS AND SYSTEMS 9+6

Modeling nonlinear inductor circuits-Inverters under tolerance band control-Nonlinear noise interactions in converters/inverters-Nonlinear phenomena in the current control of induction motors-Analysis of stability and bifurcation in power electronic induction motor drive systems

TOTAL: 75 PERIODS

COURSE OUTCOMES

Upon the completion of the course, the students will be able to

- model and analysis the power converters.
- derive transfer functions for power converters.
- design the input filters for non-linear power converters.
- realize the theory of non-linear phenomenon.
- model non-linear power electronic circuits for industrial drive applications.

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1. Erickson R.W., Maksimovic D., "Fundamentals of Power Electronics", 2nd Edition, Kluwer Academic Publishers, USA, 2004.
2. Banerjee S., Varghese G. C., "Non-linear phenomena in Power Electronics: Attractors, Bifurcations, Chaos and Non-linear control", IEEE press, New York, 2001.
3. Chi Kong Tse, "Complex Behaviour of Switching Power Converters", CRC Press, New York, 2004.
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PPS 15E07 POWER QUALITY ANALYSIS 3 0 0 3

COURSE OBJECTIVES

- To understand the power quality issues.
- To learn about the concept of power quality monitoring.
- To familiarize the concept of short interruptions & long interruptions .
- To analyse the various power quality issue and mitigation.
- To understand the active compensation techniques used for power factor correction.

UNIT 1 INTRODUCTION 9

Introduction – Characterization of Electric Power Quality: Transients, short duration and long duration voltage variations, Voltage imbalance, waveform distortion, Voltage fluctuations, Power frequency variation, Power acceptability curves – power quality problems: poor load power factor, Nonlinear and unbalanced loads, DC offset in loads, Notching in load voltage, Disturbance in supply voltage – Power quality standards.

UNIT 2 POWER QUALITY MONITORING 9

Introduction – Power quality monitoring : Need for power quality monitoring, Evolution of power quality monitoring, Deregulation effect on power quality monitoring – Power factor improvement – Brief introduction to power quality measurement equipments and power conditioning equipments – Planning, Conducting and Analyzing power quality survey – Active Filters for Harmonic Reduction.

UNIT 3 SHORT INTERRUPTIONS & LONG INTERRUPTIONS 9

Introduction – Origin of short interruptions : Voltage magnitude events due to re-closing, Voltage during the interruption – Monitoring of short interruptions –Influence on induction motors, Synchronous motors, Adjustable speed drives, Electronic equipments – Single phase tripping : Voltage during fault and post fault period, Current during fault period. Definition – Failure, Outage, Interruption – Origin of interruptions – Causes of long interruptions – Principles of regulating the voltage – Voltage regulating devices, Applications: Utility side, End-User side.

UNIT 4 ANALYSIS AND CONVENTIONAL MITIGATION METHODS 9

Analysis of power outages, Analysis of unbalance: Symmetrical components of phasor quantities, Instantaneous symmetrical components, Instantaneous real and reactive powers, Analysis of distortion: On–line extraction of fundamental sequence components from measured samples – Harmonic indices – Analysis of voltage sag: Detorit Edison sag score, Voltage sag energy, Voltage Sag Lost Energy Index (VSLEI)- Analysis of voltage flicker, Reduced duration and customer impact

of outages, Classical load balancing problem: Open loop balancing, Closed loop balancing, current balancing, Harmonic reduction, Voltage sag reduction.

UNIT 5 LOAD COMPENSATION USING DSTATCOM 9

Compensating single – phase loads – Ideal three phase shunt compensator structure – generating reference currents using instantaneous PQ theory – Instantaneous symmetrical components theory – Generating reference currents when the source is unbalanced – Realization and control of DSTATCOM – DSTATCOM in Voltage control mode

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon the completion of the course, students will be able to

- understand the various power quality issues.
- know the various methods of monitoring the power quality issues.
- distinguish short and long interruptions.
- analyse the various power quality issue and mitigation.
- demonstrate the conventional compensation techniques used for power factor correction.

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2. Power System Harmonics, Second Edition J. Arrillaga, N.R. Watson. 2003 John Wiley
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PPE 15E06 POWER ELECTRONICS IN WIND AND SOLAR POWER CONVERSION

3 0 0 3

COURSE OBJECTIVES

- To provide basic knowledge about the energy consumption and emerging trends.
- To know the concepts of solar radiation and solar cells and its application.
- To understand the concepts and recent developments in the power conditioning schemes.
- To analyse and comprehend the various operating modes of wind electrical generators.
- To understand the stand alone systems with theory of excited.

UNIT 1 INTRODUCTION 6

Trends in energy consumption - World energy scenario – Energy sources and their availability - Conventional and renewable sources - Need to develop new energy technologies.

UNIT 2 PHOTOVOLTAIC ENERGY CONVERSION AND APPLICATIONS 12

Solar radiation and measurement - Solar cells and their characteristics - Influence of insolation and temperature - PV arrays-Introduction to flexible solar cells - Electrical storage with batteries - Solar availability in India - Switching devices for solar energy conversion - Maximum power point tracking. Stand alone inverters - Charge controllers - Water pumping, Street lighting - Analysis of PV Systems.

UNIT 3 POWER CONDITIONING SCHEMES 9

DC Power conditioning Converters - Maximum Power point tracking algorithms – AC Power conditioners - Line commutated inverters - Synchronized operation with grid supply – Harmonic standards - Harmonics and PF improvement - Harmonic problems.

UNIT 4 WIND ENERGY SYSTEMS 12

Basic Principle of wind Energy conversion - Components of Wind Energy Conversion System (WECS) - Performance of Induction Generators for WECS - Classification of WECS. self excited WECS; Self Excited Induction Generator (SEIG) for isolated Power Generators – Capacitance requirements - Controllable DC Power from SEIGs . Grid Connected WECS; Grid connectors concepts - Grid related problems – Generator Control.

UNIT 5 STAND ALONE POWER SUPPLY SYSTEMS 6

Wind / Solar PV integrated systems - Selection of power conversion ratio - Optimization of system components - Storage - Reliability evolution.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon the completion of the course, the student will be able to

- know the basic concepts of energy sources and utilities.
- acquire knowledge about solar energy estimation and conversion techniques.
- understand and analyze the operation of power conditioning schemes.
- learn the fundamentals of wind energy and its conversion system.
- realize the evolution of standalone system.

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PPE 15E07 MEMS AND MICROSYSTEMS AND ITS APPLICATION 3 0 0 3

COURSE OBJECTIVES

- To impart knowledge on the design of new MEMS devices based on various principles.
- To analyse the design and modeling of electrostatic sensors and actuators.
- To familiarize the characterizing thermal sensors and actuators through design and modeling.
- To brief the fundamentals of piezoelectric sensors and actuators.
- To learn about the industrial applications of MEMS device.

UNIT I OVERVIEW OF MEMS AND MICRO SYSTEMS 9

MEMS and Microsystems- Typical MEMS and Microsystem products- Evolution of micro fabrication- Microsystems and Microelectronics- The multidisciplinary nature of microsystems design and manufacture- microsystems and miniaturization- Applications of Microsystems in the Automotive industry- Applications of Microsystems in other industries

UNIT 2 ELECTROSTATIC SENSORS AND ACTUATION 9

Introduction to Electrostatic Sensors and Actuators - Principle, material, design and fabrication of parallel plate capacitors as electrostatic sensors and actuators-Applications of Parallel Plate Capacitor-Interdigitated Finger Capacitors - Applications of Comb-Drive Devices.

UNIT 3 THERMAL SENSING AND ACTUATION 9

Introduction - Principle, material, design and fabrication of thermal couples, thermal bimorph sensors, thermal resistor sensors- Sensors and Actuators Based on Thermal Expansion - Applications.

UNIT 4 PIEZOELECTRIC SENSING AND ACTUATION 9

Origin and Expression of Piezo resistivity – Piezo resistive Sensor Materials - Piezoelectric effect-cantilever piezo electric actuator model-properties of piezoelectric materials-Applications.

UNIT 5 CASE STUDIES 9

Blood Pressure (BP) Sensor – Microphone - Acceleration Sensors – Gyros – Piezo resistive sensors, Magnetic actuation, Micro fluidics applications, Medical applications, Optical MEMS.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon the completion of the course, the student will be able to

- know about the various MEMS technology and MEMS materials.
- learn the different electrostatic sensors and actuators used in MEMS.
- find the suitable applications of MEMS sensors and actuators working based on thermal principles.
- acquire knowledge about the piezoelectric materials and sensors.
- design MEMS devices that works based on various principles.

REFERENCES

1. Chang Liu, "Foundations of MEMS", Pearson International Edition, 2006.
2. Marc Madou , "Fundamentals of microfabrication", CRC Press, 1997.
3. Boston, "Micromachined Transducers Sourcebook", WCB McGraw Hill, 1998.
4. M.H.Bao "Micromechanical transducers: Pressure sensors, accelerometers and gyroscopes", Elsevier, Newyork, 2000.
5. Tai-Ran Hsu, "MEMS and Microsystems Design and Manufacture", Tata McGraw Hill, 2002.
6. Marc Madou, "Fundamentals of micro fabrication", CRC Press, 1997.

WEB LINKS

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