**PAAVAI ENGINEERING COLLEGE, NAMAKKAL – 637 018**

**(AUTONOMOUS)**

**M.E. POWER ELECTRONICS AND DRIVES**

**REGULATIONS 2016**

**CURRICULUM**

**(CHOICE BASED CREDIT SYSTEM)**

## SEMESTER I

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PMA16105 | Applied Mathematics for Electrical Engineers | 3 | 2 | 0 | 4 |
| PPE16101 | Modeling and analysis of Electrical Machines | 3 | 2 | 0 | 4 |
| PPE16102 | Modeling and Simulation of Power Electronic Systems | 3 | 2 | 0 | 4 |
| PPE16103 | Analysis of Power Converters | 3 | 0 | 0 | 3 |
| PPE16104 | Advanced Power Semiconductor Devices | 3 | 0 | 0 | 3 |
| PP*1615* | Elective I | 3 | 0 | 0 | 3 |
| PPE16105 | Power Electronics Simulation Laboratory | 0 | 0 | 4 | 2 |
| PPE16106 | Technical Seminar I | 0 | 0 | 2 | 1 |

## SEMESTER II

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PPS16201 | Flexible AC Transmission Systems | 3 | 2 | 0 | 4 |
| PPE16202 | Solid State AC drives | 3 | 0 | 0 | 3 |
| PPE16203 | Solid State DC drives | 3 | 0 | 0 | 3 |
| PPE16204 | Embedded Control of Electrical Drives | 3 | 0 | 0 | 3 |
| PP*1625* | Elective II | 3 | 2 | 0 | 4 |
| PP*1635* | Elective III | 3 | 0 | 0 | 3 |
| PPE16205 | Electric Drives and Control Laboratory | 0 | 0 | 4 | 2 |
| PPE 16206 | Technical Seminar II | 0 | 0 | 2 | 1 |

## LIST OF ELECTIVES

## ELECTIVE I

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PPE16151 | Analysis of Inverters | 3 | 0 | 0 | 3 |
| PPE16152 | Electromagnetic Interference Issues in Power Electronics and Power systems | 3 | 0 | 0 | 3 |
| PPE16153 | Modeling of Electric Vehicles | 3 | 0 | 0 | 3 |

## ELECTIVE II

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PPS16251 | High Voltage Direct Current Transmission | 3 | 2 | 0 | 4 |
| PPS16252 | Power Quality Analysis | 3 | 2 | 0 | 4 |
| PPE16253 | Electrical Grounding | 3 | 2 | 0 | 4 |

## ELECTIVE III (OPEN ELECTIVE)

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| PPS16351 | Energy Auditing and Management | 3 | 0 | 0 | 3 |
| PPS16352 | Artificial Intelligence and its Application | 3 | 0 | 0 | 3 |

**SEMESTER I**

**PMA16105 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 familiarize the students in calculus of variations and solve problems using fourier transforms associated with engineering applications
- To understand the basic concepts of one dimensional random variables and apply in electrical engineering problems
- To formulate and construct a mathematical model for a linear programming problem in real life situation
- To introduce fourier series analysis which is central to many applications in engineering apart from its use in solving boundary value problems

**UNIT I MATRIX THEORY 15**

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

**UNIT II CALCULUS OF VARIATIONS 15**

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 15**

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 15**

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

**UNIT V FOURIER SERIES 15**

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: 75 PERIODS**

**COURSE OUTCOMES**

At the end of this course, the students will be able to

- gain a well found knowledge in matrix to calculate the electrical properties of a circuit, with voltage ,amperage ,resistance, etc.
- solve a variational problem using the Euler equation.

- gain knowledge in standard distributions which can describe the real life phenomena.
- understand and apply linear, integer programming to solve operational problem with constraints.
- apply fourier series, their different possible forms and the frequently needed practical harmonic analysis.

**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. Johnson R. A. and Gupta C. B., "Miller & Freund's Probability and Statistics for Engineers", Pearson Education, Asia, 7th Edition, 2007.


**WEB LINKS**

1. https://www.youtube.com/watch?v=8xsi296A9Co
2. https://www.youtube.com/watch?v=35UmpC6nrg8
3. https://www.youtube.com/watch?v=WWv0RUxDfbs
4. https://www.youtube.com/watch?v=8VgmBe3ulb8
5. https://www.youtube.com/watch?v=M8POtpPtQZc

**PPE16101 MODELING AND ANALYSIS OF ELECTRICAL MACHINES 3 2 0 4**

**COURSE OBJECTIVES**

- To model the DC machine and analyse its effect on various circuits.
- To analyze the steady state and dynamic state operation of DC machine through mathematical modeling.
- To model the three-phase induction machines and the operations using transformation theory.
- To impart knowledge on vector controlled induction machines.
- To learn the performance of special electrical machines using mathematical models.

**UNIT I ELECTRICAL MACHINE ANALYSIS 15**

Introduction, magnetically coupled circuits, electromechanical energy conversion, Machine Windings & Airgap MMF, Winding Inductances & Voltage Equations, equations of transformation-change of variables, Stationary circuit variables transformed to the arbitrary reference frame, Commonly used reference frames and transformation between reference frames.

**UNIT II DYNAMIC MODELING OF INDUCTION MACHINES 15**

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 III MODELING OF SYNCHRONOUS MACHINE 15**

Synchronous machine inductances –voltage equations in the rotor’s dq0 reference frame electromagnetic torque-current in terms of flux linkages-simulation of three phase synchronous machine- modeling of PM Synchronous motor.

**UNIT IV PM BL D.C. MACHINE AND LINEARIZED MACHINE 15**

Analysis of PM BL D.C. machine: Introduction to PM BL D.C. machine, Voltage and torque equations in machine variables, Analysis of steady state operations. Linearized Machine Equations: Introduction, Linearization of induction & synchronous machine equations.

**UNIT V SPECIAL MACHINES 15**

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**

At the end of this course, the students will be able to

- understand the necessity of various electrical parameters for mathematical modeling.
- know the different types of reference frame theories and transformation relationships.
- find the electrical machine equivalent circuit parameters and its modeling.

- 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, 2010.
2. Paul C. Krause, Oleg Wasynczuk and Scott D. Sudhoff, "Analysis of Electric Machinery and Drive Systems", John Wiley & Sons, 2004
3. Miller, T.J.E. "Brushless permanent magnet and reluctance motor drives", Oxford, 2014.
4. P. S. Bhimbra, "Generalised Theory of Electrical Machines ", Khanna Publications, 2013.
5. R.Krishnan "Electric Motor Drives, "Modeling, Analysis& control", Pearson Publications, 2003.
6. 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.

**PPE16102 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 know the simulate converter circuits using PSPICE and MATLAB software.
- To understand the performance of various motor drives using simulation tools.

**UNIT I INTRODUCTION 15**

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 II PSPICE 15**

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 III MATLAB AND SIMULINK 15**

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

**UNIT IV SIMULATION USING PSPICE, MATLAB AND SIMULINK 15**

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 V SIMULATION OF DRIVES 15**

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**

At the end of this course, the students 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

**PPE16103 ANALYSIS OF POWER CONVERTERS 3 0 0 3**

**COURSE OBJECTIVES**

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

**UNIT I SINGLE-PHASE CONVERTERS 9**

Single phase converters – Half controlled and fully controlled converters – Evaluation of input power factor and harmonic factor – continuous and Discontinuous load current – single phase dual converters – power factor Improvements – Extinction angle control – symmetrical angle control – single phase series converters – effect of source impedance and overlap - reactive power and power balance in converter circuits - Applications – Numerical problems.

**UNIT II THREE-PHASE CONVERTERS 9**

Three Phase Converters – Half controlled and fully controlled converters – Evaluation of input power factor and harmonic factor – continuous and Discontinuous load current – three phase dual converters — Twelve phase converters – applications –effect of source impedance- Numerical problems.

**UNIT III D.C. TO D.C. CONVERTERS 9**

Analysis of step – down and step-up dc to dc converters with resistive – inductive loads – Switched mode regulators – Analysis of Buck Regulators – Boost regulators – buck and boost regulators – Cuk regulators – Condition for Continuous inductor current and capacitor voltage – comparison of regulators – Multi-output boost converters – Advantages and Applications – Numerical problems.

**UNIT IV AC VOLTAGE CONTROLLERS 9**

Principle of ON/OFFcontrol and phase control - single phase and three phase controllers – various configurations – analysis with R and R-L loads - Harmonic analysis, Matrix converter - Numerical problems.

**UNIT V CYCLO-CONVERTERS 9**

Single phase to single phase cyclo-converters – Analysis of midpoint and bridge Configurations – Three phase to three phase cyclo-converters – analysis of Midpoint and bridge configurations – Limitations – Advantages – Applications – Numerical problems.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES**

At the end of this course, the students will be able to

- analyse the performance parameters of single and three phase AC-DC converters.
- differentiate the operating modes of various configurations of DC-DC power converters.
- design and analyse of AC to AC voltage controllers with load dependent problem.
- analyse and control the operation of cyclo-converters.

**REFERENCES**


1. Rashid M.H., “Power Electronics Circuits, Devices and Applications ", Prentice Hall India, New Delhi, 2011.
2. BimalK.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.
6. Dubey. G.K., "Thyristorised power controllers", New age International, New Delhi, 2002.


**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

**PPE16104 ADVANCED POWER SEMICONDUCTOR DEVICES 3 0 0 3**

**COURSE OBJECTIVES**

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

**UNIT I INTRODUCTION 9**

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

**UNIT II THYRISTORS 9**

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

**UNIT III 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 IV 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 V 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**

At the end of this course, the students will be able to

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

## REFERENCES


1. Rashid M.H., “Power Electronics Circuits, Devices and Applications ", Prentice Hall of India, New Delhi, 2004.
2. MD Singh and K.B Khanchandani, “Power Electronics”, Tata McGraw Hill, 2001.
3. Ned Mohan, 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., 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.

**PPE16105 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. Simulation of Single phase Semi and fully converter with
   a) R Load, b) RL load, c) RLE (Motor) Load.
2. Simulation of Single phase Dual converter.
3. Simulation of Three phase semi converter.
4. Simulation of Three phases fully controlled converter.
6. Simulation of Single phase full bridge Inverter.
7. Simulations of Three phase full bridge inverter.
   a) 180 degree mode operation, b) 120 degree mode operation
8. Simulation of single phase Sinusoidal PWM inverters.
9. Simulation of single phase multilevel inverter.
10. Simulation of Three phase AC Voltage regulator with induction motor drive.
11. Simulation of chopper fed DC motor drive.

**COURSE OUTCOMES**

At the end of this course, the students will be able to simulate and analyze various DC-DC converters, single and three phase inverters and voltage controllers.

**TOTAL: 60 PERIODS**

**PPE16106** **TECHNICAL SEMINAR I** **0 0 2 1**

**COURSE OBJECTIVES**

- To enhance the communication and presentational skills for betterment of their carrier.

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**

At the end of this course, the students will be able to help the student to acquire knowledge in communication and technical presentation skills.

**TOTAL: 30 PERIODS**

## SEMESTER II

**PPS16201 FLEXIBLE AC TRANSMISSION SYSTEMS 3 2 0 4**

**COURSE OBJECTIVES**

- To understand the concepts of transient stability and voltage stability.
- To infer knowledge on STATCOM and DSTATCOM.
- To explain the modeling and multifunction models of SSSC.
- To discuss various aspects of Unified Power Flow Controller and its characteristics.
- To describe the various thyristor controlled capacitors.

**UNIT I INTRODUCTION 15**

Concept of reactive power compensation, Review of series and shunt compensation, Concepts of transient stability and voltage stability, Power system oscillations. Basic types of FACTS controllers, benefits from FACTS controllers.

**UNIT II SHUNT COMPENSATORS 15**

Midpoint voltage regulation, Method of controlled VAR generation, principle of operation, Control and characteristics of SVC and STATCOM, Multi-control functional model of STATCOM for power flow analysis, Implementation of STATCOM models in Newton power flow, STATCOM in optimal power flow (OPF), STATCOM in distribution system (DSTATCOM), DSTATCOM performance in various modes including harmonic mitigation.

**UNIT III SERIES COMPENSATORS 15**

Series compensation and voltage stability, Variable impedance type series compensators (TCSC) and switching converter type series converter (SSSC), Configurations, Control and characteristics, General applications, Modelling of multicontrol functional model of SSSC in power flow analysis, Implemetation of SSC models in Newton power flow, SSSC in OPF, Dynamic Voltage Restorer (DVR) in Distribution System, Subsynchronous Resonance Problem, NGH Scheme.

**UNIT IV UNIFIED POWER FLOW CONTROLLERS 15**

Objectives and principle of operation of voltage and phase angle regulations, Static phase shifter and its operating characteristics, Unified Power Flow Controller (UPFC) control and characteristics, UPFC as generalised SSSC, Modelling of UPFC for power flow and OPF studies, Implementing UPFC in Newton power flow, Power oscillations control with UPFC.

**UNIT V INTERLINE POWER FLOW CONTROLLER AND CO-ORDINATION OF FACTS CONTROLLERS 15**

Principle of operation, Control and characteristics, Model of IPFC for power flow and optimum power flow studies. FACTS Controller interactions – SVC–SVC interaction, SVC-TCSC interaction, TCSC-TCSC interaction and SSSC – STATCOM interaction.

**TOTAL: 75 PERIODS**

**COURSE OUTCOMES**

At the end of this course, the students will be able to

- know the basic concepts of compensation in FACTS controller.

- understand the issues of damping to power system oscillations, real and reactive power control.
- understand the characteristics and configuration series compensators.
- compare UPFC with controlled series compensators and phase shifter.
- demonstrate the concepts of interline power flow controller and co-ordination of FACTS controllers.

**REFERENCES**

1. Song, Y.H. and Johns, A.T., Flexible AC Transmission Systems, IEEE Press, 1999.
2. Hingorani, N.G. and Gyragyi, L., Understanding FACTS (Concepts and Technology of Flexible AC Transmission System), Standard Publishers & Distributors, 2001.
3. Mathur, R.M. and Verma, R.K., Thyristor based FACTS controllers for Electrical Transmission Systems, IEEE Press 2002.
4. Zhang, X. P., Rehtanz, C. and Pal, B., Flexible AC Transmission Systems: Modelling and Control, Springer ,2006.

**WEB LINKS**

1. www.energy.siemens.com/us/en/power.../static-var-compensator-classic/
2. https://www.ee.iitb.ac.in/~npsc2008/NPSC_CD/Data/Oral/.../p236.pdf
3. new.abb.com › Offerings › FACTS

**PPE16202 SOLID STATE AC DRIVES 3 0 0 3**

**COURSE OBJECTIVES**

- To impart knowledge in operation and analysis of Induction Motors.
- To analyze the operation of 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 student to learn the controlling methods of synchronous motor drives.

**UNIT I 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 II 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 III 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 IV 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 V AC VOLTAGE CONTROLLER FED AC DRIVES 9**

Speed control and braking, Analysis of different AC motor with single and three phase ac voltage controllers. Operation in different modes and configurations. Problems and strategies.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES**

At the end of this course, the students will be able to

- analyze the concepts 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 the various methods of various field oriented control strategies.
- gain knowledge in the control methods of synchronous machine drives.

**REFERENCES**


1. S.Sivanagaraju, M.Balasubba Reddy and A.MallikariunaPrased "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.
6. Murphy J.M.D, Turnbull, F.G, “Thyristor control of AC motor, Pergamon Press, Oxford, 1988.

**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.

**PPE16203 SOLID STATE DC DRIVES 3 0 0 3**

## COURSE OBJECTIVES

- To understand dc motor system with its requirements.
- To know the speed control of dc motor.
- To study and analyze the converter for dc drives.
- To design the of controllers for dc drives.
- To know the digital control techniques of various D.C Drives.

## UNIT I REVIEW OF CONVENTIONAL DC MOTORS 9

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

## UNIT II SPEED CONTROL OF DC MOTORS 9

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

## UNIT III CONVERTER FOR DC DRIVES 9

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

## UNIT IV DESIGN OF CONTROLLERS 9

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

## UNIT V DIGITAL CONTROL OF D.C DRIVES 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

At the end of this course, the students will be able to

- know the basic concepts and behavior of dc motor.
- demonstrate the different speed control of dc motor.
- summarize the operation of converter for drives.
- 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. Electric Motors and Drives: Fundamentals, Types and Applications, Austin Hughes, Newnes, Jan 2006.
5. Control of Electrical Drives, Werner Leonhard, Springer, Sept., 2001.
6. 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.

**PPE16204 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 I MC68HC11 MICROCONTROLLER 9**

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

**UNIT II PERIPHERALS OF MC68HC11 9**

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

**UNIT III PIC 16C7X MICROCONTROLLER 9**

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

**UNIT IV PERIPHERAL OF 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 V 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**

At the end of this 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.

**REFERENCES**


1. John B. Peatman , "Design with PIC Microcontrollers", Pearson Education, 2004.
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.
4. John Iovine, “PIC Microcontroller Project Book”, McGraw Hill 2000.
5. R.Krishnan, “Electric Motor Drives, Modeling, Analysis and Control” Prentice Hall of India, 2002.

**WEB LINKS**

1. https://www.scribd.com/.../Electric-Motor-Drives-Modeling-Analysis.
2. http://www.microdesignsinc.com/picbook/bookinfo/Cover.pdf.
3. https://www.goodreads.com/author/show/281932.John_B_Peatman.

**PPE16205 ELECTRIC DRIVES AND CONTROL LABORATORY 0 0 4 2**

## COURSE OBJECTIVES

- To implement various power electronic circuits for controlling different motor drives.

## 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

At the end of this course, the students will be able to acquire requisite knowledge in various motor drives using different PED configurations.

**TOTAL: 60 PERIODS**

**PPE16206 TECHNICAL SEMINAR II 0 0 2 1**

**COURSE OBJECTIVES**

- To enhance the communication and presentational skills for betterment of their carrier.

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**

At the end of this course, the students will be able to help the student to acquire knowledge in communication and technical presentation skills.

**TOTAL: 30 PERIODS**

**ELECTIVE I**

**PPE16151 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 gain knowledge in design and the development of current source inverters.
- To analyze 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 I 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 II THREE PHASE VOLTAGE SOURCE INVERTERS 9**

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

**UNIT III CURRENT SOURCE INVERTERS 9**

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

**UNIT IV MULTILEVEL INVERTERS 9**

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

**UNIT V RESONANT INVERTERS 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**

At the end of this course, the 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.

**REFERENCES**


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.
6. Dubey. G.K., "Thyristorised power controllers", New age International, New Delhi, 2002.


**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

**PPE16152 ELECTROMAGNETIC INTERFERENCE ISSUES IN POWER ELECTONICS AND POWER SYSTEMS** **3 0 0 3**

**COURSE OBJECTIVES**

- To know the basics of electromagnetic interferences and their sources.
- To measure the noise source impedance in SMPS.
- To know the heat-sink effects in power electronic systems.
- To understand the knowledge about EMI emission of the converter.
- To know the functions of lightening surges on wind power systems.

**UNIT I INTRODUCTION 9**

Definitions of EMI/EMC -Sources of EMI- Intersystems and Intrasystem- Conducted and radiated interference- Characteristics - Designing for electromagnetic compatibility (EMC)- EMC regulation typical noise path- EMI predictions and modeling, Cross talk - Methods of eliminating interferences.

**UNIT II NOISE SOURCE IMPEDANCE MEASUREMENTS IN SMPS 9**

Topology of the model– Modifications factors calculations: differential mode current, common mode current– measurements: Impedances measurements, designable parameters: Effect of the material, Effect of the size of the choke- State of the art of noise impedance measurements in SMPS– Theory of the direct clamping two-probe measurement.

**UNIT III HEATSINK EMI EFFECTS IN POWER ELECTRONIC SYSTEMS 9**

Analytical function of a complex variable, Antenna– Common mode coupling- Direct FET package– Finite Difference Time Domain (FDTD) – Heatsink– Laplace's equation– Radiation pattern– Rectangular cavity– Switching transients.

**UNIT IV EMI EMISSION OF THE CONVERTER FED AC MOTOR DRIVES 9**

Introduction– Generation of Common Mode Currents in ASD– Broadband Modeling of AC Motor Windings– Modeling of an AC Motor Feeding Cable– Feeding Cable Impact on the Motor CM Currents.

**UNIT V LIGHTENING SURGES ON WIND POWER SYSTEMS 9**

Introduction– Frequency control- Wind farm protection and fault ride through– communication requirements– supervisory control and data acquisition– Other requirements: metering, start and stop, modeling and validation– grid connectivity and evacuation arrangements– complementary commercial mechanisms– special dispensation for scheduling of wind and solar generation.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES**

At the end of this course, the students will be able to

- know electromagnetic interferences and their sources.
- be familiar with the noise source impedance in SMPS.
- summarize the effects of heat sink in power electronic systems.
- gain the knowledge about EMI Emission on the converter.
- define the lightening effects on wind power systems.

**REFERENCES**

1. S.M. Muyeen, Wind Energy Conversion Systems: Technology and Trends, Springer Publications,2011.
2. Firuz Zare, Electromagnetic Interference Issues in Power Electronics and Power Systems, Bentham Science Publishers,2010.
3. Weston David A., "Electromagnetic Compatibility", Principles and Application, 1991.

**WEB LINKS**

1. http://www.adv-radio-sci.net/9/317/2011/ars-9-317-2011.pdf
2. http://ebooks.benthamscience.com/book/9781608052400/

**PPE16153 MODELLING OF ELECTRIC VEHICLES 3 0 0 3**

**COURSE OBJECTIVES**

- To provide the basic concepts of the electric vehicle and different kinds of operating modes.
- To brief the EV configuration with motor drive techniques and analysis the system parameters.
- To make the students to gain knowledge on modeling of HEV system.
- To familiarize the concepts of various motor drives and storage devices for EV application.
- To understand the design and power management of PHEVs

**UNIT I INTRODUCTION 9**

Electric vehicle and the Environment - Usage patterns for electric road vehicles - Types of electric vehicle-EV Architecture: Battery Electric Vehicles - the IC engine / Electric hybrid vehicle - Fuelled EVs - EVs using Supply lines - EVs which use Flywheels or super capacitors - solar powered vehicles - vehicles using linear motors.

**UNIT II EV SYSTEM 9**

EV configurations: Fixed and variable gearing - single and multiple motor drives - In wheel drives. EV parameters: weight and size parameters - force parameters - energy parameters - performance parameters.

**UNIT III HEV MODELING 9**

Modeling for energy Analysis - vehicle level energy analysis: equation of motion - forward and backward modeling approaches - vehicle energy balance, power train components: internal combustion engine-torque converter - Gear ratios and mechanical gearbox - Electric machines-batteries.

**UNIT IV ELECTRONIC PROPULSION AND ENERGY SOURCES 9**

EV considerations - DC motor drives - Induction motor Drives - permanent magnet motor drives -switched reluctance motor drives. Battery - Fuel cells - Ultra capacitors.

**UNIT V PLUG - IN HYBRID ELECTRIC VEHICLES 9**

PHEV Architectures - Equivalent electric range of blended PHEVs – Power management of PHEVs - PHEV design and component sizing - component sizing of blended PHEV - HEV to PHEV conversions -vehicle to grid technology.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES**

At the end of this course, the students will be able to

- understand the concept of various electric vehicle .
- analyze the working of electric vehicle system.
- analyze the HEV system.
- know the operation and its characteristic of various types of motor and storage devices .
- design the conversion of plug-in HEV.

**REFERENCES**


1. James Larminie, John Lowry, “Electric Vehicle Technology”, John Wiley & Sons, 2012.
2. C. C. Chan, K. T. Chau, “Modern Electric Vehicle Technology”, Oxford University Press, 2001.
3. Simona Onori, Lorenzo Serrao, Giorgio Rizzoni, “Hybrid Electric Vehicles: Energy Management Strategies”, Springer, 2015.
4. Chris Mi, M. Abul Masrur, David Wenzhong Gao, “Hybrid Electric Vehicles: Principles and Applications with with Practical Perspectives”, John Wiley & Sons, 2011.


**WEB LINKS**

1. https://books.google.co.in/books?id=IdPZ3NYhF68C&dq=Electric+Vehicles&source=gbs_navlinks_s
2. https://www.youtube.com/watch?v=BMrA-5EDakg
3. http://nptel.ac.in/courses/108103009/

**ELECTIVE II**

**PPS16251 HIGH VOLTAGE DIRECT CURRENT TRANSMISSION 3 2 0 4**

**COURSE OBJECTIVES**

- To discuss the basic concepts of HVDC with existing HVDC projects.
- To analyze the HVDC Converters and HVDC System Control and harmonics and filtering.
- To gain knowledge about the types of Multi terminal DC Systems.
- To understand the concepts of power flow analysis in AC/DC systems.
- To explain the basic concepts of simulation of HVDC systems.

**UNIT I DC POWER TRANSMISSION TECHNOLOGY 15**

Introduction - Comparison of AC and DC transmission – Application of DC transmission – Description of DC transmission system - Planning for HVDC transmission – Modern trends in DC transmission – DC breakers – Cables, VSC based HVDC.

**UNIT II ANALYSIS OF HVDC CONVERTERS AND HVDC SYSTEM CONTROL 15**

Pulse number, choice of converter configuration – Simplified analysis of Graetz circuit - Converter bridge characteristics – characteristics of a twelve pulse converter- detailed analysis of converters. General principles of DC link control – Converter control characteristics – System Control hierarchy - Firing angle control – Current and extinction angle control – Generation of harmonics and filtering - power control – Higher level controllers.

**UNIT III MULTITERMINAL DC SYSTEMS 15**

Introduction – Potential applications of MTDC systems - Types of MTDC systems - Control and protection of MTDC systems - Study of MTDC systems.

**UNIT IV POWER FLOW ANALYSIS IN AC/DC SYSTEMS 15**

Per unit system for DC Quantities - Modeling of DC links - Solution of DC load flow - Solution of AC-DC power flow - Case studies.

**UNIT V SIMULATION OF HVDC SYSTEMS 15**

Introduction – System simulation: Philosophy and tools – HVDC system simulation – Modeling of HVDC systems for digital dynamic simulation – Dynamic in traction between DC and AC systems.

**TOTAL: 75 PERIODS**

**COURSE OUTCOMES**

At the end of this course, the students will be able to

- understand the basic concept of DC power transmission technology.
- analyze HVDC converters and HVDC system control with converter.
- know the concepts of multi terminal DC systems with control and protection of MTDC system.
- analyze the solution of AC/DC power flow analysis.
- design the simulation of HVDC systems with Philosophy and tools.

**REFERENCES**


1. K.R.Padiyar, , "HVDC Power Transmission Systems", New Age International (P) Ltd., New Delhi, 2010.
2. J.Arrillaga, , "High Voltage Direct Current Transmission", Peter Pregrinus, London,1983.
3. P. Kundur, "Power System Stability and Control", McGraw-Hill, 2000.
4. ErichUhlmann, "Power Transmission by Direct Current", BS Publications, 2004.
5. V.K.Sood,HVDC and FACTS controllers – Applications of Static Converters in Power System,April 2004 , Kluwer Academic Publishers.
6. S.Kakshaish, V.Kamaraju, "HVDC Transmission", TMH Publishers, 2012.


**WEB LINKS**


1. www.newagepublishers.com/samplechapter/000356.pdf
2. https://library.e.abb.com/public/.../cepex99.pdf
3. www.sari-energy.org/...We...Power_Systems.../lecture_11.pdf

**PPS16252** **POWER QUALITY ANALYSIS** **3 2 0 4**

**COURSE OBJECTIVES**

- To understand the concepts of the power quality Issues.
- To explain the power and energy measurements, power factor measurements.
- To infer knowledge on single phase voltage sag.
- To describe the power quality considerations in industries.
- To discuss the mitigation of interruptions and voltage sags

**UNIT I INTRODUCTION 15**

Introduction of the Power Quality (PQ) problem, Terms used in PQ: Voltage, Sag, Swell, Surges, Harmonics, over voltages, spikes, Voltage fluctuations, Transients, Interruption, overview of power quality phenomenon, Remedies to improve power quality, power quality monitoring.

**UNIT II LONG & SHORT INTERRUPTIONS 15**

Interruptions – Definition – Difference between failures, outage, Interruptions – causes of Long Interruptions – Origin of Interruptions – Limits for the Interruption frequency – Limits for the interruption duration – costs of Interruption – Overview of Reliability evaluation to power quality, comparison of observations and reliability evaluation.

**Short Interruptions:** definition, origin of short interruptions, basic principle, fuse saving, voltage magnitude events due to re-closing, voltage during the interruption, monitoring of short interruptions, difference between medium and low voltage systems. Multiple events, single phase tripping – voltage and current during fault period, voltage and current at post fault period, stochastic prediction of short interruptions.

**UNIT III 1 & 3-PHASE VOLTAGE SAG CHARACTERIZATION 15**

Voltage sag – definition, causes of voltage sag, voltage sag magnitude, and monitoring, theoretical calculation of voltage sag magnitude, voltage sag calculation in non-radial systems, meshed systems, and voltage sag duration. Three phase faults, phase angle jumps, magnitude and phase angle jumps for three phase unbalanced sags, load influence on voltage sags.

**UNIT IV POWER QUALITY CONSIDERATIONS IN INDUSTRIAL POWER SYSTEMS 15**

Voltage sag – equipment behavior of Power electronic loads, induction motors, synchronous motors, computers, consumer electronics, adjustable speed AC drives and its operation. Mitigation of AC Drives, adjustable speed DC drives and its operation, mitigation methods of DC drives.

**UNIT V MITIGATION OF INTERRUPTIONS & VOLTAGE SAGS 15**

Overview of mitigation methods – from fault to trip, reducing the number of faults, reducing the fault clearing time changing the power system, installing mitigation equipment, improving equipment immunity, different events and mitigation methods. System equipment interface – voltage source converter, series voltage controller, shunt controller, combined shunt and series controller.

**TOTAL: 75 PERIODS**

**COURSE OUTCOMES**

At the end of this course, the students will be able to

- discuss the various power quality issues.
- understand the concept of power and energy measurements, power factor measurements.
- know the concept of single and three phase voltage sag.
- gain knowledge in the power quality considerations in industrial power.
- use the concept of mitigation of interruptions & voltage sags.

**REFERENCES**


1. Math H J Bollen , "Understanding Power Quality Problems", IEEE Press, 2000.
2. R. SastryVedam Mulukutla S. Sarma , "Power Quality VAR Compensation in Power Systems", CRC Press, 2008.
3. C. Sankaran, "Power Quality", CRC Press, 2001.
4. Roger C. Dugan , Mark F. Mc Granaghan, H. Wayne Beaty, "Electrical Power Systems Quality", Tata McGraw Hill , 2012


**WEB LINKS**

1. www.materialdownload.in/article/Power-Quality-Enhancement-Using-Custom-Power-Devices
2. read.pudn.com/downloads156/.../Power%20System%20Harmonics.pdf
3. accessengineeringlibrary.com/.../electrical-power-systems-quality-third-edition.

**PPE16253 ELECTRICAL GROUNDING 3 2 0 4**

**COURSE OBJECTIVES**

- To understand the concept of grounding of power supply system.
- To infer knowledge on the equipment grounding.
- To elucidate the ground electrode system & soil resistance.
- To describe the electrical noise and mitigation. .
- To discuss the grounding practices on UPS systems.

**UNIT I INTRODUCTION 15**

Bonding - Lightning and its effect on electrical systems - Static charges and the need for bonding-Ground electrodes and factors affecting their efficacy - Noise in signaling circuits and protective measures: shielding-Surge protection of electronic equipment - UPS systems and their role in power quality improvement - ungrounded systems - Solidly grounded systems - Impedance grounding using neutral reactor - Resonant grounding using neutral reactor - Impedance grounding through neutral resistance Point of grounding.

**UNIT II EQUIPMENT GROUNDING 15**

Shock hazard Grounding of equipment-Operation of protective devices -Thermal capability -Touch Potential during ground faults- Induced voltage problem -Mitigation by multiple ground connection- Mitigation by reduction of conductor spacing-EMI suppression- Metal enclosures for grounding conductors- Grounding connections for surge protection equipment -Sensing of ground faults- Equipotential bond.

**UNIT III GROUND ELECTRODE SYSTEM 15**

Grounding electrodes-Soil resistance -Measurement of soil resistivity -Resistance of a single rod electrode -Current-carrying capacity of an electrode -Use of multiple ground rods in parallel -Measurement of ground resistance of an electrode-Concrete-encased electrode -Corrosion problems in electrical grounding systems -Maintenance of grounding system -Chemical electrodes.

**UNIT IV ELECTRICAL NOISE AND MITIGATION 15**

Definition of electrical noise and measures for noise reduction -Frequency analysis of noise-Categories of noise-Disturbances from other equipment in the same distribution system -Earth loop as a cause of noise-The ways in which noise can enter a signal cable and its control -More about shielding -Shielded isolation transformer-Avoidance of earth loop-Use of insulated ground (IG) receptacle -Zero signal reference grid and signal-transport ground plane Harmonics in electrical systems.

**UNIT V UPS SYSTEMS AND THEIR GROUNDING PRACTICES 15**

Power quality issues-Definitions of abnormal voltage conditions-Susceptibility and measures to handle voltage abnormalities Regulating transformer-Standby sources-Electromechanical UPS systems-Solid-state UPS systems -Multiple units for redundancy Considerations in selection of UPS systems for ADP facilities-Grounding issues in static UPS -configurations UPS configurations and recommended grounding practices.

**TOTAL: 75 PERIODS**

## COURSE OUTCOMES

At the end of this course, the students will be able to

- understand the concept of grounding of power supply system.
- gain knowledge in the equipment grounding.
- explain the ground electrode system and soil resistance.
- analyse the electrical noise and mitigation.
- enumerate the grounding practices on UPS systems.

## REFERENCES


1. G Vijayaraghavan, Mark Brown, Malcolm Barnes Butterworth-Heinemann, "Practical Grounding, Bonding, Shielding and Surge Protection" Newnes is an imprint of Elsevier 2004.
2. Phil Simmons, "Electrical Grounding and Bonding" Based on the 2011 NEC Codes 2014.
3. James G. Stallcup, James W. Stallcup," Electrical Grounding and Bonding Simplified" Based on the NEC Codes and Standards 2002.


## WEB LINKS

1. https://www.engineereducators.com/docs/groundingandbonding2-2.pdf
2. https://www.progress-energy.com/assets/www/docs/business/Grounding.pdf
3. https://www.mikeholt.com/instructor2/img/product/pdf/1292432628sample.pdf

**ELECTIVE III**

**PPS16351 ENERGY AUDITING AND MANAGEMENT 3 0 0 3**

**COURSE OBJECTIVES**

- To discuss and analyse the various energy security energy auditing
- To analyze the various method in energy auditing and economics
- To impact knowledge of the energy efficient in motors and transformers
- To explain the various method of reactive power management and lighting
- To describe the auditing of cogeneration and conservation in industries

**UNIT I INTRODUCTION 9**

Power system security, factors affecting power system security, contingency analysis, linear sensitivity factors, contingency selection, concentric relaxation, calculation of network sensitivity factors. Transmission planning criteria.

**UNIT II ENERGY AUDITING AND ECONOMICS 9**

System approach and End use approach to efficient use of Electricity; Electricity tariff types ;Energy auditing-Types and objectives-audit instruments –ECO assessment and Economic methods-cash flow model, time value of money, evaluation of proposals, pay-back method, average rate of return method, internal rate of return method, present value method, profitability index, life cycle costing approach, investment decision and uncertainty, consideration of income taxes, depreciation and inflation in investment analysis- specific energy analysis-Minimum energy paths- consumption models.

**UNIT III ENERGY EFFICIENT MOTORS AND TRANSFORMERS 9**

Electric motors-Energy efficient controls- Motor Efficiency and Load Analysis-Energy efficient/high efficient Motors Load Matching and selection of motors. Variable speed drives -Pumps and Fans- Efficient Control strategies- Optimal selection and sizing – Optimal operation and Storage. Transformer Loading /Efficiency analysis, Feeder /cable Loss evaluation.

**UNIT IV REACTIVE POWER MANAGEMENT AND LIGHTING 9**

Reactive Power management –Capacitor Sizing-Degree of Compensation-Capacitor losses-Location-Placement-Maintenance-Case study. Economics of power factor improvement. Peak Demand controls- Methodologies – Types of Industrial Loads-Optimal Load scheduling-Case study. Lightning-Energy efficient light sources-Energy Conservation in lighting schemes. Electronic Ballast-Power quality issues-Luminaries.

**UNIT V COGENERATION AND CONSERVATION IN INDUSTRIES 9**

Cogeneration-Types and Schemes-Optimal operation of cogeneration plants- Case study. Electric loads of Air conditioning and Refrigeration –Energy conservation measures-Cool storage- Types- Optimal operation-Case study .Electric water heating-Geysers-Solar Water Heaters-Power Consumption in Compressors, Energy conservation measures-Electrolytic Process-Computer Control-Software –EMS.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES**

At the end of this course, the students will be able to

- understand various factor affecting power system security
- classify the various methods involved in energy auditing and economics
- obtain the knowledge in the energy efficient motors and transformers
- know the various technologies for reactive power management and lighting.
- understand the various technologies to conserve energy in electrical systems.

**REFERENCES**


1. Giovanni Petrecca,Industrial Energy Management :Principles and Application,The Kluwer international series-207,(1999)
2. Anthony J.Pansini,Kenneth .D. Smalling ,Guide to Electric Load Management , Pennwell Pub;(1998)
3. Howard .E.Jordan.Energy – Efficient Electric Motors and Their Applications ,Pleneum Pub Corp.2ndedition(1994)
4. Turner ,Wayne C ,Energy Management /Handbook,Lilburn,The Fairmont Press,2001.
5. Albert Thumann ,Handbook of Energy Audits,Fairmont Press 5thEdition (1998)


**WEBLINKS**

1. nptel.ac.in/courses/120108004/module5/lecture5.pdf
2. www.nptel.ac.in/syllabus/108106022/
3. www.em-ea.org

**PPS16352 ARTIFICIAL INTELLIGENCE AND ITS APPLICATION 3 0 0 3**

**COURSE OBJECTIVES**

- To describe the artificial intelligence networks.
- To discuss the fuzzy logic operations.
- To analyze the application of genetic algorithm.
- To knowledge on neural networks and its real-time performance.
- To understand the PSO and DE techniques

**UNIT I INTRODUCTION TO NEURAL NETWORKS 9**

Basics of ANN – Perceptron -Delta learning rule –Back Propagation Algorithm- Multilayer Feed forward network-Memory models-Bi-directional associative memory-Hopfield network. Application of Neural Networks to load forecasting, Contingency Analysis-VAR control, Economic Load Dispatch.

**UNIT II INTRODUCTION TO FUZZY LOGIC 9**

Crispness-Vagueness-Fuzziness-Uncertainty-Fuzzy set theory Fuzzy sets-Fuzzy set operations-fuzzy measures-fuzzy relations-fuzzy function. Structure of fuzzy logic controller-fuzzification models-data base-rule base-inference engine defuzzification module. Control Schemes.

**UNIT III APPLICATIONS TO AI TECHNIQUES 9**

Decision making Control through fuzzy set theory-Use of fuzzy set models of LP and its scheduling problems-Fuzzy logic based power stabilizer.

**UNIT IV GENETIC ALGORITHM AND ITS APPLICATIONS 9**

Introduction – Simple Genetic Algorithm – Reproduction,.Crossover, Mutation, Advanced Operators in Genetic Search – Applications to voltage Control and Stability Studies.

**UNIT V PSO AND DE TECHNIQUES 9**

Introduction – Review on PSO and DE –Restoration using ParticleSwarm Optimization and Differential Evolution techniques - Formulation, applications.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES**

At the end of this course, the students will be able to

- understand the basics of design aspects of neural networks.
- know the fundamentals of fuzzy logic.
- use the fundamentals of genetic algorithm and application
- differentiate the fuzzy logic, genetic algorithm and neural networks in power systems.
- understand the basics of PSO and DE.

**REFERENCES**

1. James.A.Freeman and B.M.Skapura "Neural Networks, Algorithms Applications and Programming techniques"- Addison Wesley, 2000.

2. GeorgeKlir and Tina Folger,.A., “Fuzzy sets, Uncertainty and Information”, Prentice Hall of India Pvt.Ltd., 2002 .
3. Zimmerman,H.J. “Fuzzy Set Theory and its Applications”, Kluwer Academic Publishers,2004.
4. IEEE tutorial on “Application of Neural Network to Power Systems”, 2010
5. Loi Lei Lai, “Intelligent System Applications in Power Engineering”, John Wiley and Sons Ltd., 1998.

**WEB LINKS**

1. www.seattlerobotics.org/encoder/mar98/fuz/flindex.html
2. www.journals.elsevier.com/engineering-applications-of-artificial-intellige.
3. www.softcomputing.net/aciis.pdf