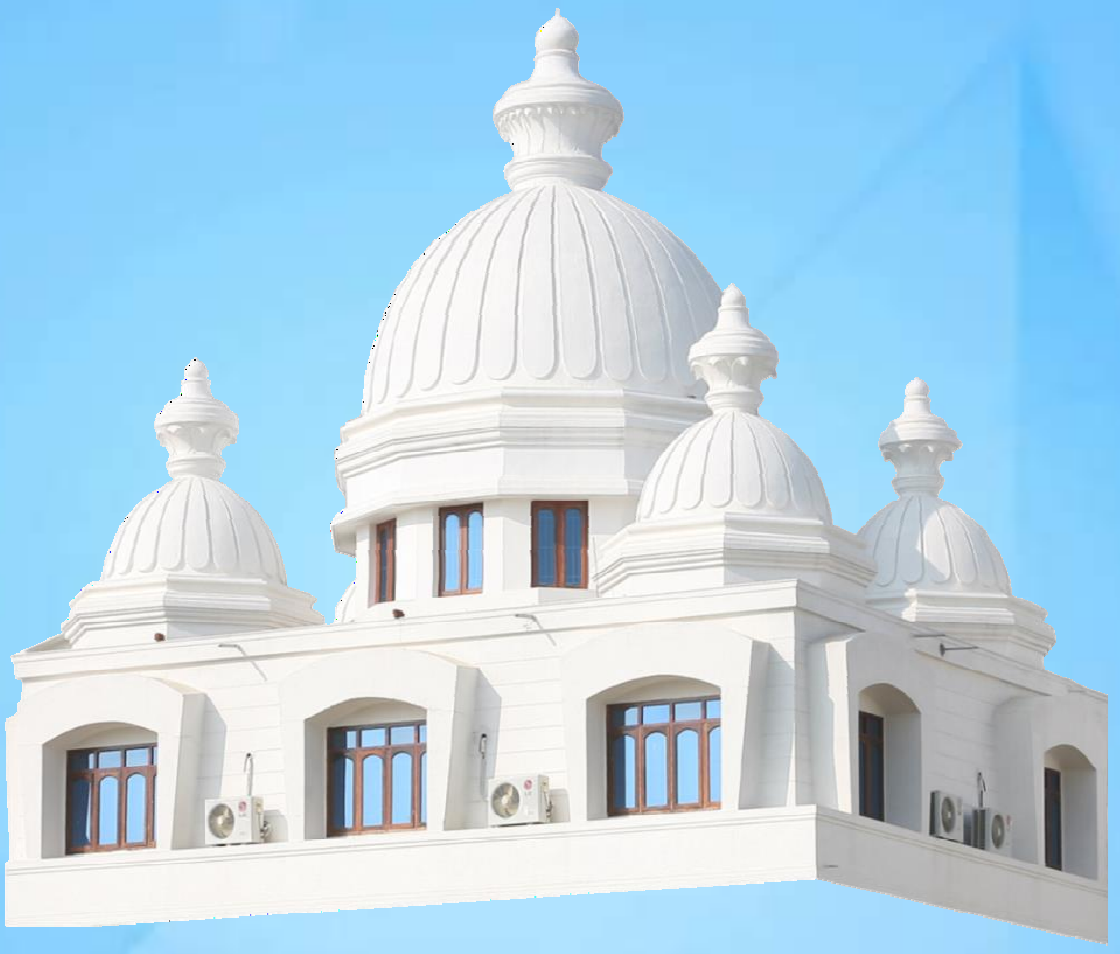
# M.E. – POWER ELECTRONICS AND DRIVES

## R-2020: Curriculum & Syllabus



# ENGINEERING COLLEGE

## (Autonomous)

**Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai**

**Accredited by NBA and NAAC with "A+"and Recognized by UGC (2f&12B)**

**KOMARAPALAYAM – 637303**

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# EXCEL ENGINEERING COLLEGE

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**DEPARTMENT OF EEE REGULATION 2020**
**M.E –POWER ELECTRONICS AND DRIVES**
**Curriculum for Semesters – I, II, III & IV**

| I – SEMESTER | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Code No. | Course | Category | Periods / Week | | | C | Maximum Marks | | |
| | | | L | T | P | | CA | FE | Total |
| **Theory Course(s)** | | | | | | | | | |
| 20PMA104 | Applied Mathematics for Electronics Engineers | FC | 3 | 2 | 0 | 4 | 40 | 60 | 100 |
| 20PPE101 | Power Semiconductor Devices | PC | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 20PPE102 | Analysis of Electrical Machines | PC | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 20PPE103 | Analysis and Design of Power Converters | PC | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 20PPEEXX | Professional Elective I | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 20PPEEXX | Professional Elective II | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| **Practical Course** | | | | | | | | | |
| 20PPE104 | Power Electronics Circuits Laboratory | PC | 0 | 0 | 4 | 2 | 50 | 50 | 100 |
| **TOTAL** | | | 18 | 2 | 4 | 21 | 290 | 350 | 700 |

| II- SEMESTER | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Code No. | Course | Category | Periods / Week | | | C | Maximum Marks | | |
| | | | L | T | P | | CA | FE | Total |
| **Theory Course(s)** | | | | | | | | | |
| 20PPE201 | Analysis and Design of Inverters | PC | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 20PPE202 | Solid State Drives | PC | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 20PPE203 | Special Electrical Machines | PC | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 20PPE204 | Power Quality | PC | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 20PPEEXX | Professional Elective-III | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 20PPEEXX | Professional Elective IV | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |

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| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Practical Course** | | | | | | | | | |
| 20PPE205 | Electrical Drives Laboratory | PC | 0 | 0 | 4 | 2 | 50 | 50 | 100 |
| 20PPE206 | Mini Project | EEC | 0 | 0 | 4 | 2 | 50 | 50 | 100 |
| | | **Total** | **18** | **0** | **8** | **22** | **340** | **460** | **800** |

**III – SEMESTER**

| Code No. | Course | Category | Periods / Week | | | C | Maximum Marks | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | | CA | FE | Total |
| **Theory Course(s)** | | | | | | | | | |
| 20PTE301 | Research Methodology and IPR | PC | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 20PPE302 | Power Electronics for Renewable Energy Systems | PC | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 20PPEEXX | Professional Elective V | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| **Practical Course** | | | | | | | | | |
| 20PPE303 | Project Work Phase- I | EEC | 0 | 0 | 12 | 6 | 50 | 50 | 100 |
| | | **Total** | **9** | **0** | **12** | **15** | **170** | **230** | **400** |

**IV- SEMESTER**

| Code No. | Course | Category | Periods / Week | | | C | Maximum Marks | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | | CA | FE | Total |
| **Practical Course** | | | | | | | | | |
| 20PPE401 | Project Work Phase -II | EEC | 0 | 0 | 24 | 12 | 50 | 50 | 100 |
| | | **Total** | **0** | **0** | **24** | **12** | **50** | **50** | **100** |

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| LIST OF PROFESSIONAL ELECTIVES | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Code No. | Course | Category | Periods / Week | | | C | Maximum Marks | | |
| | | | L | T | P | | CA | FE | Total |
| **Theory Course(s)** | | | | | | | | | | |
| **Semester I- Elective I** | | | | | | | | | | |
| 20PPEE01 | Soft Computing Techniques | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 20PPEE02 | Electromagnetic Field Computation and Modeling | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 20PPEE03 | Control System Design for Power Electronics | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| **Semester I- Elective II** | | | | | | | | | | |
| 20PPEE11 | Analog and Digital Controllers | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 20PPEE12 | Flexible AC Transmission Systems | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 20PPEE13 | Distributed Generation and Micro grid | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| **Semester II- Elective III** | | | | | | | | | | |
| 20PPEE21 | Modern Rectifiers and Resonant Converters | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 20PPEE22 | Computer Aided Simulation and Design of Power Electronics Systems | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 20PPEE23 | Field Programmable Gate Array Design | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| **Semester II- Elective IV** | | | | | | | | | | |
| 20PPEE31 | High Voltage Direct Current Transmission | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 20PPEE32 | Solar and Energy Storage Systems | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 20PPEE33 | Non Linear Control | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 20PPEE34 | Electric Vehicles and Power Management | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |

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| Semester III- Elective V | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 20PPEE41 | Wind Energy Conversion Systems | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 20PPEE42 | Energy Management and Auditing | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 20PPEE43 | Smart Grid | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 20PPEE44 | Electric Vehicles | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |

| S. No | Category | CREDITS PER SEMESTER | | | | Total Credit (AICTE) | Credits in % |
|---|---|---|---|---|---|---|---|
| | | I | II | III | IV | | |
| 1. | FC | 4 | | | | 4 | 5.71% |
| 2. | BS | | | | | | |
| 3. | ES | | | | | | |
| 4. | PC | 11 | 14 | 6 | | 31 | 44.28% |
| 5. | PE | 6 | 6 | 3 | | 15 | 21.42% |
| 6. | OE | | | | | | |
| 7. | EEC | | 2 | 6 | 12 | 20 | 28.57% |
| Total | | 21 | 22 | 15 | 12 | 70 | 100.00% |

FC - Foundation Courses

BS - Basic Sciences

ES - Engineering Sciences

PC - Professional Core

PE - Professional Electives

OE - Open Electives

EEC - Employability Enhancement Courses

CA - Continuous Assessment

FE - Final Examination

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## I SEMESTER

| 20PMA104 | APPLIED MATHEMATICS FOR ELECTRONICS ENGINEERS | L | T | P | C |
|---|---|---|---|---|---|
| | | 4 | 0 | 0 | 4 |
| Nature of Course | Fundamental Core | | | | |
| Pre requisites | Basic Engineering Mathematics | | | | |

**Course Objectives**

The course is intended to

1. The main objective of this course is to demonstrate various analytical skills in applied mathematics.
2. Understand the extensive experience with the tactics of problem solving and logical thinking applicable for the students of electrical engineering.
3. To study performance of mathematical tools from a variety of mathematical areas, including matrix theory.
4. To study identify, formulate, abstract, and solve problems in electrical engineering.
5. To study the calculus of variations, probability, linear programming and Fourier series.

**Course Outcomes**

On successful completion of the course, students will be able to

| CO.No. | Course Outcome | Bloom's Level |
|---|---|---|
| CO1 | Apply various methods in matrix theory to solve system of linear equations | Applying |
| CO2 | Maximizing and minimizing the functional that occur in electrical engineering discipline | Applying |
| CO3 | Computation of probability and moments, standard distributions of discrete and continuous random variables and functions of a random variable | Understand |
| CO4 | Could develop a fundamental understanding of linear programming models, able to develop a linear programming model from problem description, apply the simplex method for solving linear programming problems | Understand |
| CO5 | Fourier series analysis and its uses in representing the power signals | Analyzing |

**Course Contents:**

**UNIT I MATRIX THEORY** 12

Cholesky decomposition - Generalized Eigenvectors - Canonical basis - QR factorization - Least squares method - Singular value decomposition.

**UNIT II CALCULUS OF VARIATIONS** 12

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

**UNIT III PROBABILITY AND RANDOM VARIABLES** 12

Probability – Axioms' of probability – Conditional probability – Baye's theorem - 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** 12
Formulation – Graphical solution – Simplex method – Big M method - Two phase method. Transportation and Assignment models.

**UNIT V FOURIER SERIES** 12
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: 60 PERIODS**

**REFERENCES:**


1. Andrews L.C. and Phillips R.L., "Mathematical Techniques for Engineers and Scientists", Prentice Hall of India Pvt. Ltd., New Delhi, 2015.
2. Bronson, R. "Matrix Operation", Schaum's outline series, 2nd Edition, McGraw Hill, 2011.
3. Elsgolc, L. D. "Calculus of Variations", Dover Publications, New York, 2019.
4. Johnson, R.A., Miller, I and Freund J., "Miller and Freund's Probability and Statistics for Engineers", Pearson Education, Asia, 9th Edition, 2019.
5. O'Neil, P.V., "Advanced Engineering Mathematics", Thomson Asia Pvt. Ltd., Singapore, 2003.
6. Taha, H.A., "Operations Research, An Introduction", 9th Edition, Pearson education, New Delhi, 2018.


**Mapping of Course Outcomes (COs) with Program Outcomes (POs) Program Specific Outcomes (PSOs)**

| COs | POs | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| CO1 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO2 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO3 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO4 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO5 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| | 3 | High | | | | 2 | Medium | | | | | 1 | Low | | 0 |

| Formative assessment | | | |
|---|---|---|---|
| **Bloom's Level** | **Assessment Component** | **Marks** | **Total marks** |
| Remember | Classroom or Online Quiz | 5 | 15 |
| Understand | Class Presentation/Power point presentation | 5 | |
| | Attendance | 5 | |

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| 20PPE101 | POWER SEMICONDUCTOR DEVICES | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| Nature of Course | Professional Core | | | | |
| Pre requisites | Fundamental of Power Semiconductor Devices | | | | |

**OBJECTIVES**

1. To improve power semiconductor device structures for adjustable speed motor control applications.
2. To understand the static and dynamic characteristics of current controlled power semiconductor devices.
3. To understand the static and dynamic characteristics of voltage controlled power semiconductor devices.
4. To enable the students for the selection of devices for different power electronics applications.
5. To understand the control and firing circuit for different devices.

**Course Outcomes**

On successful completion of the course, students will be able to

| CO.No. | Course Outcome | Bloom's Level |
|---|---|---|
| CO1 | Determine the suitable device for the application | Analyzing |
| CO2 | To design of semiconductor device and its parameters | Analyzing |
| CO3 | Design of protection circuits | Understand |
| CO4 | Design of control circuits | Understand |
| CO5 | Determine the reliability of the system | Understand |

**Course Contents:**

**UNIT I INTRODUCTION** 9

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

**UNIT II CURRENT CONTROLLED DEVICES** 9

BJT's – Construction, static characteristics, switching characteristics; Negative temperature coefficient and second breakdown; - Thyristors – Physical and electrical principle underlying operating mode, Two transistor analogy – concept of latching; Gate and switching characteristics; converter grade and inverter grade and other types; series and parallel operation; comparison of BJT and Thyristor – steady state and dynamic models of BJT &Thyristor- Basics of GTO, MCT, FCT, RCT.

**UNIT III VOLTAGE CONTROLLED DEVICES** 9

Power MOSFETs and IGBTs – Principle of voltage controlled devices, construction, types,static and switching characteristics, steady state and dynamic models of MOSFET and IGBTs - and IGCT, New semiconductor materials for devices – Intelligent power modules- Integrated gate commutated thyristor (IGCT) - Comparison of all power devices.

**UNIT IV FIRING AND PROTECTING CIRCUITS** 9

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

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**UNIT V THERMAL PROTECTION** 9

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

**TOTAL: 45 PERIODS**

**REFERENCES:**


1. B.W Williams 'Power Electronics Circuit Devices and Applications' Third Edition, New Delhi, 2014.
2. Rashid M.H., " Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Third Edition, New Delhi, 2018
3. MD Singh and K.B Khanchandani, "Power Electronics", Tata McGraw Hill, 2017.
4. Mohan, Undeland and Robins, "Power Electronics – Concepts, applications and Design, John Wiley and Sons, Singapore, 2020.
5. Joseph Vithayathil, Power Electronics: Principles and Applications, Delhi, Tata McGraw- Hill, 2020.


**Mapping of Course Outcomes (COs) with Program Outcomes (POs) Program Specific Outcomes (PSOs)**

| COs | POs | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| CO1 | 3 | 2 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO2 | 3 | 2 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO3 | 3 | 2 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO4 | 3 | 2 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO5 | 3 | 2 | 2 | | | | | | | | | | 3 | 2 | 3 |
| | 3 | High | | | | 2 | Medium | | | | | 1 | Low | | |

**Formative assessment**

| Bloom's Level | Assessment Component | Marks | Total marks |
|---|---|---|---|
| Remember | Classroom or Online Quiz | 5 | 15 |
| Understand | Class Presentation/Power point presentation | 5 | |
| | Attendance | 5 | |

**Summative Assessment**

| Bloom's Category | Continuous Assessment Tests | | | Terminal Examination (60) |
|---|---|---|---|---|
| | 1 (7.5) | 2 (7.5) | 3 (10) | |
| Remember | 10 | 10 | 10 | 20 |
| Understand | 10 | 10 | 10 | 20 |
| Apply | 0 | 0 | 0 | 0 |
| Analyse | 30 | 30 | 30 | 60 |
| Evaluate | 0 | 0 | 0 | 0 |
| Create | 0 | 0 | 0 | 0 |

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| 20PPE102 | Analysis of Electrical Machines | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| Nature of Course | Professional Core | | | | |
| Pre requisites | Design of Electrical Machines | | | | |

**OBJECTIVES:**

1. To provide knowledge about the fundamentals of magnetic circuits, energy, force and torque of multi-excited systems.
2. To analyze the steady state and dynamic state operation of DC machine through mathematical modeling and simulation in digital computer.
3. To provide the knowledge of theory of transformation of three phase variables to two phase variables.
4. To analyze the steady state and dynamic state operation of three-phase induction machines using transformation theory based mathematical modeling and digital computer simulation.
5. To analyze the steady state and dynamic state operation of three-phase synchronous machines using transformation theory based mathematical modeling and digital computer simulation.

**Course Outcomes**

On successful completion of the course, students will be able to

| CO.No. | Course Outcome | Bloom's Level |
|---|---|---|
| CO1 | Formulate time domain and frequency domain description of Wide Sense Stationary process in terms of matrix algebra and relate to linear algebra concepts. | Apply |
| CO2 | State W-K theorem, spectral factorization theorem, spectrum estimation, bias and consistency of estimators. | Understand |
| CO3 | Determine the State the Linear Filtering and Wiener filtering. | Apply |
| CO4 | Inductions LMS algorithms, Levinson recursion algorithm, applications of adaptive filters | Apply |
| CO5 | Decimation, interpolation, Sampling rate conversion, Applications of multirate signal processing | Apply |

**Course Contents:**

**UNIT I PRINCIPLES OF ELECTROMAGNETIC ENERGY CONVERSION** 9

Magnetic circuits, permanent magnet, stored magnetic energy, co-energy - force and torque in singly and doubly excited systems – machine windings and air gap mmf - winding inductances and voltage equations.

**UNIT II DC MACHINES** 9

Elementary DC machine and analysis of steady state operation - Voltage and torque equations dynamic characteristics of permanent magnet and shunt d.c. motors – Time domain block diagrams - solution of dynamic characteristic by Laplace transformation – digital computer simulation of permanent magnet and shunt D.C. machines.

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**UNIT III REFERENCE FRAME THEORY** 9

Historical background – phase transformation and commutator transformation – transformation of variables from stationary to arbitrary reference frame - variables observed from several frames of reference.

**UNIT IV INDUCTION MACHINES** 9

Three phase induction machine, equivalent circuit and analysis of steady state operation – free acceleration characteristics – voltage and torque equations in machine variables and arbitrary reference frame variables – analysis of dynamic performance for load torque variations – digital computer simulation.

**UNIT V SYNCHRONOUS MACHINES** 9

Three phase synchronous machine and analysis of steady state operation - voltage and torque equations in machine variables and rotor reference frame variables (Park's equations) – analysis of dynamic performance for load torque variations – Generalized theory of rotating electrical machine and Krons primitive machine.

**TOTAL: 45 PERIODS**

**REFERENCES:**


1. Paul C.Krause, Oleg Wasyzczuk, Scott S, Sudhoff, "Analysis of Electric Machinery and Drive Systems", John Wiley, Second Edition, 2020.
2. P S Bimbhra, "Generalized Theory of Electrical Machines", Khanna Publishers, 2018.
3. A.E, Fitzgerald, Charles Kingsley, Jr, and Stephan D, Umanx, " Electric Machinery", Tata McGraw Hill, 8th Edition, 2018.
4. R. Krishnan, Electric Motor & Drives: Modeling, Analysis and Control, New Delhi, Prentice Hall of India, 2019.


**Mapping of Course Outcomes (COs) with Program Outcomes (POs) Program Specific Outcomes (PSOs)**

| COs | POs | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| CO1 | 3 | 2 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO2 | 3 | 2 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO3 | 3 | 2 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO4 | 3 | 2 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO5 | 3 | 2 | 2 | | | | | | | | | | 3 | 2 | 3 |
| | 3 | High | | | | 2 | Medium | | | | | 1 | Low | | |

| Formative assessment | | | |
|---|---|---|---|
| **Bloom's Level** | **Assessment Component** | **Marks** | **Total marks** |
| Remember | Classroom or Online Quiz | 5 | 15 |
| Understand | Class Presentation/Power point presentation | 5 | |
| | Attendance | 5 | |

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| Summative Assessment | | | | |
|---|---|---|---|---|
| Bloom's Category | Continuous Assessment Tests | | | Terminal Examination (60) |
| | 1 (7.5) | 2 (7.5) | 3 (10) | |
| Remember | 10 | 10 | 10 | 20 |
| Understand | 10 | 10 | 10 | 20 |
| Apply | 30 | 30 | 30 | 60 |
| Analyse | 0 | 0 | 0 | 0 |
| Evaluate | 0 | 0 | 0 | 0 |
| Create | 0 | 0 | 0 | 0 |

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| 20PPE103 | ANALYSIS AND DESIGN OF POWER CONVERTERS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| Nature of Course | Professional Core | | | | |
| Pre requisites | Basic Power Electronics | | | | |

**OBJECTIVES:**

1. To determine the operation and characteristics of controlled rectifiers.
2. To apply switching techniques and basic topologies of DC-DC switching regulators.
3. To introduce the design of power converter components.
4. To provide an in depth knowledge about resonant converters.
5. To comprehend the concepts of AC-AC power converters and their applications.

**Course Outcomes**

On successful completion of the course, students will be able to

| CO.No. | Course Outcome | Bloom's Level |
|---|---|---|
| CO1 | Analyze the synthesis, Simulation and testing of systems | Analyzing |
| CO2 | Apply different high performance algorithms in ASICs | Apply |
| CO3 | Applied to Logic Synthesis and testing. | Apply |
| CO4 | Use the FPGA tools and Routing for commutate design | Understand |
| CO5 | Discuss the design issues of SOC. | Understand |

**Course Contents:**

**UNIT I SINGLE PHASE & THREE PHASE CONVERTERS** 9

Principle of phase controlled converter operation – single-phase full converter and semi- converter (RL,RLE load)- single phase dual converter – Three phase operation full converter and semi-converter (R,RL,RLE load) – reactive power – power factor improvement techniques –PWM rectifiers.

**UNIT II DC-DC CONVERTERS** 9

Limitations of linear power supplies, switched mode power conversion, Non-isolated DC- DC converters: operation and analysis of Buck, Boost, Buck-Boost, Cuk& SEPIC – under continuous and discontinuous operation – Isolated converters: basic operation of Flyback, Forward and Push-pull topologies.

**UNIT III DESIGN OF POWER CONVERTER COMPONENTS** 9

Introduction to magnetic materials- hard and soft magnetic materials –types of cores , copper windings – Design of transformer –Inductor design equations –Examples of inductor design for buck/flyback converter-selection of output filter capacitors – selection of ratings for devices – input filter design.

**UNIT IVRESONANT DC-DC CONVERTERS** 9

Switching loss, hard switching, and basic principles of soft switching- classification of resonant converters- load resonant converters – series and parallel – resonant switch converters – operation and analysis of ZVS, ZCS converters comparison of ZCS/ZVS- Introduction to ZVT/ZCT PWM converters.

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**UNIT V VAC-AC CONVERTERS** 9

Principle of on-off and phase angle control – single phase ac voltage controller – analysis with R & RL load – Three phase ac voltage controller – principle of operation of cyclo converter – single phase and three phase cyclo converters – Introduction to matrix converters.

**TOTAL: 45 PERIODS**

**REFERENCES:**


1 Ned Mohan,T.MUndeland and W.P Robbin, "Power Electronics: converters, Application and design" John Wiley and sons.Wiley India edition, 2016.

2 Rashid M.H., "Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Third Edition, New Delhi, 2019.

3 P.C. Sen, "Modern Power Electronics", Wheeler Publishing Co, First Edition, New Delhi, 2018.

4 P.S.Bimbra, "Power Electronics", Khanna Publishers, Eleventh Edition, 2013.


**Mapping of Course Outcomes (COs) with Program Outcomes (POs) Program Specific Outcomes (PSOs)**

| COs | POs | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| CO1 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| CO2 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| CO3 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| CO4 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| CO5 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| | 3 | High | | | | 2 | Medium | | | | | 1 | Low | | |

| Formative assessment | | | |
|---|---|---|---|
| **Bloom's Level** | **Assessment Component** | **Marks** | **Total marks** |
| Remember | Classroom or Online Quiz | 5 | 15 |
| Understand | Class Presentation/Power point presentation | 5 | |
| | Attendance | 5 | |

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| Summative Assessment | | | | |
|---|---|---|---|---|
| Bloom's Category | Continuous Assessment Tests | | | Terminal Examination (60) |
| | 1 (7.5) | 2 (7.5) | 3 (10) | |
| Remember | 10 | 10 | 10 | 20 |
| Understand | 10 | 10 | 10 | 20 |
| Apply | 30 | 30 | 30 | 60 |
| Analyse | 0 | 0 | 0 | 0 |
| Evaluate | 0 | 0 | 0 | 0 |
| Create | 0 | 0 | 0 | 0 |

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| 20PPE104 | Power Electronics Circuits Laboratory | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 4 | 2 |
| Nature of Course | Devices and Circuits | | | | |
| Pre requisites | Fundamentals of Power Electronics | | | | |

**Course Objectives**

1. To provide an insight on the switching behaviours of power electronic switches.
2. To make the students familiar with the digital tools used in generation of gate pulses for the power electronic switches.
3. To make the students capable of implementing analog interfacing as well as control circuits used in a closed-loop control for power electronic system
4. To make the students acquire knowledge on mathematical modeling of power electronic circuits and implementing the same using simulation tools.
5. To facilitate the students to design and fabricate a power converter circuits at appreciable voltage/power levels.

**Course Outcomes**

1. Comprehensive understanding on the switching behaviour of Power Electronic Switches Environments
2. Comprehensive understanding on mathematical modeling of power electronic system and ability to implement the same using simulation tools
3. Ability of the student to use microcontroller and its associated IDE* for power electronic applications
4. Ability of the student to design and implement analog circuits for Power electronic control applications
5. Ability to design and fabricate a power converter circuit at an reasonable power level

**CYCLE-1**

| S.No. | Course Content | CO | Bloom's Level |
|---|---|---|---|
| 1 | Study of switching characteristics of Power electronic switches with and without Snubber (i) IGBT (ii) MOSFET | CO1 | Applying |
| 2 | Modeling and system simulation of basic electric circuits using MATLAB- SIMULINK/SCILAB | CO1 | Applying |
| 3 | DC source fed resistive load and Resistive-inductive load. | CO4 | Applying |
| 4 | DC source fed RLC load for different damping conditions | CO2 | Applying |
| 5 | DC source fed DC motor load | CO5 | Applying |
| 6 | Modeling and System simulation of basic power electronic circuits using MATLAB-SIMULINK/SCILAB | CO4 | Applying |

## CYCLE-2

| S.No. | Course Content | CO | Bloom's Level |
|---|---|---|---|
| 1 | Three phase sine PWM inverter | CO5 | Applying |
| 2 | Generation of PWM gate pulses with duty cycle control using PWM peripheral of microcontroller ( TI-C2000 family/ PIC18) | CO4 | Applying |
| 3 | Duty cycle control from IDE | CO3 | Applying |
| 4 | Duty Cycle control using a POT connected to ADC peripheral in a standalone mode | CO4 | Applying |
| 5 | Generation of Sine-PWM pulses for a three phase Voltage Source Inverter with control of modulation index using PWM peripheral of microcontroller (TI C2000 family/PIC 18) | CO4 | Applying |
| 6 | Design of Driver Circuit using IR2110 | CO4 | Applying |

**Mapping of Course Outcomes (COs) with Program Outcomes (POs) Program Specific Outcomes (PSOs)**

| COs | POs | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| CO1 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| CO2 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| CO3 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| CO4 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| CO5 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| | 3 | High | | | | 2 | Medium | | | | | 1 | Low | | |

**Summative assessment based on Continuous and End Semester Examination**

| Bloom's Level | Internal Assessment [50 marks] | End Semester Examination [50 marks] |
|---|---|---|
| Remember | 10 | 10 |
| Understand | 20 | 20 |
| Apply | 40 | 40 |
| Analyze | 30 | 30 |
| Evaluate | - | - |
| Create | - | - |

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## II SEMESTER

| 20PPE201 | Analysis and Design of Inverters | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| Nature of Course | Professional Core | | | | |
| Pre requisites | Basic Power Electronics | | | | |

**Course Objective**

1. To provide the electrical circuit concepts behind the different working modes of inverters so as to enable deep understanding of their operation.
2. To equip with required skills to derive the criteria for the design of inverters for UPS, drives etc.,
3. To analyse and comprehend the various operating modes of different configurations of inverters.
4. To design different single phase and three phase inverters.
5. To impart knowledge on multilevel inverters and modulation techniques

**Course Outcomes**

On successful completion of the course, students will be able to

| CO.No. | Course Outcome | Bloom's Level |
|---|---|---|
| CO1 | Get expertise in the working modes and operation of inverters | Analyzing |
| CO2 | Design single phase and three phase inverters | Apply |
| CO3 | To formulate and design the inverters for generic loads and machine loads | Apply |
| CO4 | Multilevel inverters and modulation techniques | Understand |
| CO5 | Analyze the various concept of inverter topology. | Analyze |

**Course Contents:**

**UNIT I SINGLE PHASE INVERTERS** 9

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

**UNIT II THREE PHASE VOLTAGE SOURCE INVERTERS** 9

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

**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 – PWM techniques for current source inverters.

**UNIT IV MULTILEVEL & BOOST INVERTERS** 9

Multilevel concept – diode clamped – flying capacitor – cascade type multilevel inverters - Comparison of multilevel inverters - application of multilevel inverters – PWM techniques for MLI – Single phase & Three phase Impedance source inverters.

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**UNIT V RESONANT INVERTERS AND POWER CONDITIONERS** TOTAL: 45 PERIODS

Series and parallel resonant inverters - voltage control of resonant inverters – Class E resonant inverter – resonant DC - link inverters.-power line disturbances-power conditioners-UPS: offline UPS, online UPS.

**TEXT BOOKS**


1. Rashid M.H., "Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Third Edition, New Delhi, 2014.
2. Jai P.Agrawal, "Power Electronics Systems", Pearson Education, Second Edition, 2012
3. BimalK.Bose "Modern Power Electronics and AC Drives", Pearson Education, fourth Edition, 2013.
4. Ned Mohan,T.MUndeland and W.P Robbin, "Power Electronics: converters, Application and design" John Wiley and sons.Wiley India edition, 2016
5. Philip T. krein, "Elements of Power Electronics" Oxford University Press -1998.


**REFERENCE BOOKS**


1. P.C. Sen, "Modern Power Electronics", Wheeler Publishing Co, First Edition, New Delhi, 2018.
2. P.S.Bimbra, "Power Electronics", Khanna Publishers, Eleventh Edition, 2013.


**Mapping of Course Outcomes (COs) with Program Outcomes (POs) Program Specific Outcomes (PSOs)**

| COs | POs | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| CO1 | 3 | 3 | | | | | | | | | | 2 | 3 | 2 | 3 |
| CO2 | 3 | 3 | | | | | | | | | | 2 | 3 | 2 | 3 |
| CO3 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| CO4 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| CO5 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| | 3 | High | | | | 2 | Medium | | | | | 1 | Low | | |

| Formative assessment | | | |
|---|---|---|---|
| **Bloom's Level** | **Assessment Component** | **Marks** | **Total marks** |
| Remember | Classroom or Online Quiz | 5 | 15 |
| Understand | Class Presentation/Power point presentation | 5 | |
| | Attendance | 5 | |

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| Summative Assessment | | | | |
|---|---|---|---|---|
| Bloom's Category | Continuous Assessment Tests | | | Terminal Examination (60) |
| | 1 (7.5) | 2 (7.5) | 3 (10) | |
| Remember | 10 | 10 | 10 | 20 |
| Understand | 10 | 10 | 10 | 20 |
| Apply | 30 | 30 | 30 | 60 |
| Analyse | 0 | 0 | 0 | 0 |
| Evaluate | 0 | 0 | 0 | 0 |
| Create | 0 | 0 | 0 | 0 |

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| 20PPE202 | Solid State Drives | L 3 | T 0 | P 0 | C 3 |
|---|---|---|---|---|---|
| Nature of Course | Professional Core | | | | |
| Pre requisites | Fundamentals of power Electronics and Electrical Machines | | | | |

**Course Objectives**

**The course is intended to**

1. To study and analyze the operation of the converter / chopper fed DC drives, both qualitatively and quantitatively.
2. To familiarize the students on the operation of VSI and CSI fed induction motor drives.
3. To understand the field oriented control of induction machines
4. To impart knowledge on the control of synchronous motor drives

**Course Outcomes**

On successful completion of the course, students will be able to

| CO.No. | Course Outcome | Bloom's Level |
|---|---|---|
| CO1 | Will be able to formulate, design and analyze power supplies for generic loads and machine loads. | Analyze |
| CO2 | Will acquire knowledge on the operation of VSI and CSI fed induction motor drives. | Understand |
| CO3 | Will get expertise in the field oriented control of Induction motor drives. | Understand |
| CO4 | Will be able to formulate the control schemes for synchronous motor drives. | Analyze |
| CO5 | Apply the evolutionary optimization techniques | Apply |

**Course Contents**

**Unit-I RECTIFIER CONTROL OF DC DRIVES** 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.

**Unit-II CHOPPER CONTROL OF DC DRIVES** 9

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

**Unit-III CONTROL OF INDUCTION MOTOR DRIVES- STATOR SIDE AND ROTOR SIDE** 9

AC voltage controller circuit – six step inverter voltage control-closed loop variable frequency PWM inverter with dynamic braking-CSI fed variable frequency drives – comparison Static rotor resistance control - injection of voltage in the rotor circuit – static scherbius drives - power factor considerations – modified Kramer drives.

**Unit-IV FIELD ORIENTED CONTROL OF INDUCTION MOTOR DRIVES** 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.

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**Unit-V SYNCHRONOUSMOTOR DRIVES** 9

Wound field cylindrical rotor motor – Equivalent circuits – performance equations for operation from a voltage source – starting and braking - V curves - Self control-margin angle control-torque

**TOTAL : 45PERIODS**

**REFERENCE BOOKS**


1 P.C Sen "Thyristor DC Drives", John wiely and sons, New York, 2015.
2 Gopal K Dubey, "Power Semiconductor controlled Drives", Prentice Hall Inc., New Jersy, 2018.
3 Gopal K.Dubey, "Fundamentals of Electrical Drives", Narosa Publishing House, New Delhi, Second Edition ,2019.
4 Bimal K Bose, "Modern Power Electronics and AC Drives", Pearson Education Asia 2002.
5 R.Krishnan, "Electric Motor Drives – Modeling, Analysis and Control", Prentice-Hall of India Pvt. Ltd., New Delhi, 2016.
6 VedamSubramanyam, "Electric Drives – Concepts and Applications", Tata McGraw-Hill publishing company Ltd., New Delhi, 2012.
7 W.Leonhard, "Control of Electrical Drives", Narosa Publishing House, 2018.
8 Murphy J.M.D and Turnbull, "Thyristor Control of AC Motors", Pergamon Press, Oxford, 2017.


**Mapping of Course Outcomes (COs) with Program Outcomes (POs) Program Specific Outcomes (PSOs)**

| COs | POs | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| CO1 | 2 | 3 | | | | | | | | | | 1 | 3 | 2 | 2 |
| CO2 | 3 | 3 | | | | | | | | | | 1 | 3 | 2 | 2 |
| CO3 | 2 | 3 | | | | | | | | | | 1 | 3 | 2 | 2 |
| CO4 | 3 | 2 | | | | | | | | | | 1 | 3 | 2 | 2 |
| CO5 | 3 | 3 | | | | | | | | | | 1 | 3 | 2 | 2 |
| | 3 | High | | | | 2 | Medium | | | | | 1 | Low | | |

| Formative assessment | | | |
|---|---|---|---|
| **Bloom's Level** | **Assessment Component** | **Marks** | **Total marks** |
| Remember | Classroom / Online Quiz/Group discussion | 5 | 15 |
| Understand | Class Presentation/Power point presentation | 5 | |
| | Attendance | 5 | |

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| Summative Assessment | | | | |
|---|---|---|---|---|
| Bloom's Category | Continuous Assessment Tests | | | Terminal Examination (60) |
| | 1 (7.5) | 2 (7.5) | 3 (10) | |
| Remember | 10 | 10 | 10 | 20 |
| Understand | 10 | 10 | 10 | 20 |
| Apply | 30 | 30 | 30 | 60 |
| Analyse | 0 | 0 | 0 | 0 |
| Evaluate | 0 | 0 | 0 | 0 |
| Create | 0 | 0 | 0 | 0 |

Passed in Board of Studies Meeting (09.10.2021)

Approved in Academic Council Meeting (11.10.2021)

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| 20PPE203 | Special Electrical Machines | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| Nature of Course | Professional Core | | | | |
| Pre requisites | Fundamentals of Electrical Machines | | | | |

**Course Objectives**

1. To review the fundamental concepts of permanent magnets and the operation of permanent magnet brushless DC motors.
2. To introduce the concepts of permanent magnet brushless synchronous motors and synchronous reluctance motors.
3. To develop the control methods and operating principles of switched reluctance motors.
4. To introduce the concepts of stepper motors and its applications.
5. To understand the basic concepts of other special machines

**Course Outcomes**

On successful completion of the course, students will be able to

| CO.No. | Course Outcome | Bloom's Level |
|---|---|---|
| CO1 | Understand the open loop and closed loop systems stepper motors. | Understand |
| CO2 | Classitity the characteristics of special machines | Understand |
| CO3 | Compare of the control methods of special motors. | Analyze |
| CO4 | Select the suitable motor for a certain job under given conditions | Apply |
| CO5 | Analyze various types drives used for certain load | Analyze |

**Course Contents**

**UNIT I PERMANENT MAGNET BRUSHLESS DC MOTORS** 9

Fundamentals of Permanent Magnets- Types- Principle of operation- Magnetic circuit analysis EMF and Torque equations- Characteristics and control.

**UNIT II PERMANENT MAGNET SYNCHROUNOUS MOTORS** 9

Principle of operation – EMF and Torque equations - Phasor diagram - Power controllers – Torque speed characteristics – Digital controllers – Constructional features, operating principle and characteristics of synchronous reluctance motor.

**UNIT III SWITCHED RELUCTANCE MOTORS** 9

Constructional features –Principle of operation- Torque prediction–Characteristics-Power controllers – Control of SRM drive- Sensorless operation of SRM – Applications.

**UNIT IV STEPPER MOTORS** 9

Constructional features –Principle of operation –Types – Torque predictions – Linear and Non-linear analysis – Characteristics – Drive circuits – Closed loop control –Applications.

**UNIT V OTHER SPECIAL MACHINES** 9

Principle of operation and characteristics of Hysteresis motor – AC series motors – Linear motor Applications.

**TOTAL : 45 PERIODS**

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**TEXT BOOKS**


1. T.J.E. Miller, 'Brushless magnet and Reluctance motor drives', Claredon press, London, 2013.
2. R.Krishnan, ' Switched Reluctance motor drives' , CRC press, 2017.
3. T.Kenjo, ' Stepping motors and their microprocessor controls', Oxford University press, New Delhi, 2016.


**REFERENCE BOOKS**


1. R.Krishnan, ' Electric motor drives' , Prentice hall of India,2012.
2. D.P.Kothari and I.J.Nagrath, ' Electric machines', Tata Mc Graw hill publishing company, New Delhi, Third Edition, 2014.
3. Irving L.Kosow, "Electric Machinery and Transformers" Pearson Education, Second Edition, 2017.


Mapping of Course Outcomes (COs) with Program Outcomes (POs) Program Specific Outcomes (PSOs)

| COs | POs | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| CO1 | 2 | 3 | 2 | | | | | | | | | | 3 | 2 | 2 |
| CO2 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 2 |
| CO3 | 2 | 3 | 2 | | | | | | | | | | 3 | 2 | 2 |
| CO4 | 3 | 2 | 2 | | | | | | | | | | 3 | 2 | 2 |
| CO5 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 2 |
| | 3 | High | | | | 2 | Medium | | | | | 1 | Low | | |

| Formative assessment | | | |
|---|---|---|---|
| Bloom's Level | Assessment Component | Marks | Total marks |
| Remember | Classroom / Online Quiz/Group discussion | 5 | 15 |
| Understand | Class Presentation/Power point presentation | 5 | |
| | Attendance | 5 | |

| Summative Assessment | | | | |
|---|---|---|---|---|
| Bloom's Category | Continuous Assessment Tests | | | Terminal Examination (60) |
| | 1 (7.5) | 2 (7.5) | 3 (10) | |
| Remember | 10 | 10 | 10 | 20 |
| Understand | 10 | 10 | 10 | 20 |
| Apply | 30 | 30 | 30 | 60 |
| Analyse | 0 | 0 | 0 | 0 |
| Evaluate | 0 | 0 | 0 | 0 |
| Create | 0 | 0 | 0 | 0 |

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| 20PPE204 | Power Quality | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| Nature of Course | Professional Core | | | | |
| Pre requisites | Fundamentals of Electrical Engineering | | | | |

**Course Objectives**

The course is intended to

1. To understand the various power quality issues.
2. To understand the concept of power and power factor in single phase and three phase
3. systems supplying nonlinear loads.
4. To understand the conventional compensation techniques used for power factor correction and load voltage regulation.
5. To understand the active compensation techniques used for power factor correction.
6. To understand the active compensation techniques used for load voltage regulation.

**Course Outcomes**

On successful completion of the course, students will be able to

| CO.No. | Course Outcome | Bloom's Level |
|---|---|---|
| CO1 | To formulate, design and simulate power supplies for generic load. | Apply |
| CO2 | Infer harmonic analysis on power supplies and drive systems. | Analysis |
| CO3 | and design load compensation methods useful for mitigating quality problems. | Apply |
| CO4 | Ability to formulate, design and simulate power supplies for machine loads. | Apply |
| CO5 | To conduct load tests on power supplies and drive systems. | Apply |

**Course Contents**

**UNIT I 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, Non linear and unbalanced loads, DC offset in loads, Notching in load voltage, Disturbance in supply voltage – Power quality standards.

**UNIT II ANALYSIS OF SINGLE PHASE AND THREE PHASE SYSTEM** 9

Single phase sinusoidal, non sinusoidal source supplying linear and nonlinear loads – Three phase Balance system – Three phase unbalanced system – Three phase unbalanced and distorted source supplying non linear loads – Concept of PF – Three phase three wire – Three phase four wire system.

**UNIT III CONVENTIONAL LOAD COMPENSATION METHODS** 9

Principle of Load compensation and Voltage regulation – Classical load balancing problem : Open loop balancing – Closed loop balancing, Current balancing – Harmonic reduction and voltage sag reduction – Analysis of unbalance – instantaneous real and reactive powers – Extraction of fundamental sequence component.

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**UNIT IV LOAD COMPENSATION USING DSTATCOM** 1

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.

**UNIT V SERIES COMPENSATION OF POWER DISTRIBUTION SYSTEM** 1

Rectifier supported Dynamic Voltage Restorer – DC Capacitor supported DVR – DVR Structure – voltage Restoration – Series Active Filter – Unified Power Quality Conditioner.

**TOTAL: 45 PERIODS**

**TEXT BOOKS**


1 ArindamGhosh "Power Quality Enhancement Using Custom Power Devices", Kluwer Academic Publishers, 2012

2 R.C. Duggan, Mark.F.McGranaghan,SuryaSantoas and H.WayneBeaty, "Electrical Power System Quality", McGraw-Hill, 2014.


**REFERENCE BOOKS**


1 Jos Arrillaga and Neville R. Watson ," Power system harmonics",Wiley,2013.
Derek A. Paice , "Power Electronics Converter Harmonics :Multipulse Methods for Clean Power",Wiley,2017.

2. Ewald Fuchs, Mohammad A. S. Masoum Power Quality in Power Systems and Electrical Machines,Elseveir academic press publications,2021.


**Mapping of Course Outcomes (COs) with Program Outcomes (POs) Program Specific Outcomes (PSOs)**

| COs | POs | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| CO1 | 2 | 3 | | 3 | | | | | | | | 1 | 3 | 2 | 2 |
| CO2 | 3 | 3 | | 3 | | | | | | | | 1 | 3 | 2 | 2 |
| CO3 | 2 | 3 | | 2 | | | | | | | | 1 | 3 | 2 | 2 |
| CO4 | 3 | 2 | | 3 | | | | | | | | 1 | 3 | 2 | 2 |
| CO5 | 3 | 3 | | 3 | | | | | | | | 2 | 3 | 2 | 2 |
| | 3 | High | | | | 2 | Medium | | | | | 1 | Low | | |

| Bloom's Level | Formative assessment<br>Assessment Component | Marks | Total marks |
|---|---|---|---|
| Remember | Classroom / Online Quiz/Group discussion | 5 | 15 |
| Understand | Class Presentation/Power point presentation | 5 | |
| | Attendance | 5 | |

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| Summative Assessment | | | | |
|---|---|---|---|---|
| Bloom's Category | Continuous Assessment Tests | | | Terminal Examination (60) |
| | 1 (7.5) | 2 (7.5) | 3 (10) | |
| Remember | 10 | 10 | 10 | 20 |
| Understand | 10 | 10 | 10 | 20 |
| Apply | 30 | 30 | 30 | 60 |
| Analyse | 0 | 0 | 0 | 0 |
| Evaluate | 0 | 0 | 0 | 0 |
| Create | 0 | 0 | 0 | 0 |

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| 20PPE205 | Electrical Drives Laboratory | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 4 | 2 |
| Nature of Course | Devices and Circuits | | | | |
| Pre requisites | Fundamentals of Power Electronics and Electrical Machines | | | | |

**Course Objectives**

1. To design and analyse the various DC and AC drives
2. To generate the firing pulses for converters using digital processors
3. To generate the firing pulses for inverters using digital processors
4. Design of controllers for linear and nonlinear systems.
5. Implementation of closed loop system using hardware simulation

**Course Outcomes**

1. To learn about electrical drives system.
2. Ability to simulate different types of machines in a system
3. Ability to simulate different types of converters in a system
4. Analyze the performance of various electric drive systems
5. Ability to perform both hardware and software simulation

**CYCLE-1**

| S.No. | Course Content | CO | Bloom's Level |
|---|---|---|---|
| 1 | Speed control of Converter fed DC motor | CO1 | Applying |
| 2 | Speed control of Chopper fed DC motor | CO1 | Applying |
| 3 | V/f control of three-phase induction motor | CO4 | Applying |
| 4 | Micro controller based speed control of Stepper motor | CO2 | Applying |
| 5 | Speed control of BLDC motor | CO5 | Applying |

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## CYCLE-2

| S.No. | Course Content | CO | Bloom's Level |
|---|---|---|---|
| 1 | DSP based speed control of SRM motor | CO5 | Applying |
| 2 | Voltage Regulation of three-phase Synchronous Generator | CO4 | Applying |
| 3 | Cycloconverter fed Induction motor drives | CO3 | Applying |
| 4 | Single phase Multi Level Inverter based induction motor drive | CO4 | Applying |
| 5 | Study of power quality analyzer using FACT Controller | CO4 | Applying |

**Mapping of Course Outcomes (COs) with Program Outcomes (POs) Program Specific Outcomes (PSOs)**

| COs | POs | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| CO1 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| CO2 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| CO3 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| CO4 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| CO5 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| | 3 | High | | | | 2 | Medium | | | | | 1 | Low | | |

| Summative assessment based on Continuous and End Semester Examination | | |
|---|---|---|
| Bloom's Level | Internal Assessment [50 marks] | End Semester Examination [50 marks] |
| Remember | 10 | 10 |
| Understand | 20 | 20 |
| Apply | 40 | 40 |
| Analyze | 30 | 30 |
| Evaluate | - | - |
| Create | - | - |

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## LIST OF PROFESSIONAL ELECTIVES
## SEMESTER-I

| 20PPEE01 | Soft Computing Techniques | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| Nature of Course | Professional Elective | | | | |
| Pre requisites | Basic o f NN,FLS,GA | | | | |

**Course Objectives**

1. To expose the concepts of feed forward neural networks.
2. To provide adequate knowledge about feedback neural networks.
3. To teach about the concept of fuzziness involved in various systems.
4. To expose the ideas about genetic algorithm
5. To provide adequate knowledge about of FLC and NN toolbox

**Course Outcomes**

On successful completion of the course, students will be able to

| CO.No. | Course Outcome | Bloom's Level |
|---|---|---|
| CO1 | To know the basic ANN architectures, algorithms and their limitations. | Analyzing |
| CO2 | Able to know the different operations on the fuzzy sets. | Apply |
| CO3 | Expertise in the use of different ANN structures and online training algorithm. | Apply |
| CO4 | knowledgeable to use Fuzzy logic for modeling and control of non-linear systems. | Apply |
| CO5 | Competent to use hybrid control schemes and P.S.O and support vector Regressive. | Apply |

**Course Contents:**

**UNIT I INTRODUCTION AND ARTIFICIAL NEURAL NETWORKS** 9

Introduction to intelligent systems- Soft computing techniques- Conventional Computing versus Swarm Computing - Classification of meta-heuristic techniques - Properties of Swarm intelligent Systems - Application domain - Discrete and continuous problems - Single objective and multi-objective problems -Neuron- Nerve structure and synapse- Artificial Neuron and its model- activation functions- Neural network architecture- single layer and multilayer feed forward networks- Mc Culloch Pitts neuron model- perceptron model- Adaline and Madaline- multilayer perception model- back propogation learning methods- effect of learning rule coefficient -back propagation algorithm- factors affecting back propagation training- applications.

**UNIT II ARTIFICIAL NEURAL NETWORKS AND ASSOCIATIVE MEMORY** 9

Counter propagation network- architecture- functioning & characteristics of counter Propagation network- Hopfield/ Recurrent network configuration - stability constraints associative memory and characteristics- limitations and applications- Hopfield v/s Boltzman machine- Adaptive Resonance Theory- Architecture- classifications- Implementation and training - Associative Memory.

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**UNIT III FUZZY LOGIC SYSTEM** 9

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

**UNIT IV GENETIC ALGORITHM** 9

Evolutionary programs – Genetic algorithms, genetic programming and evolutionary programming - Genetic Algorithm versus Conventional Optimization Techniques - Genetic representations and selection mechanisms; Genetic operators- different types of crossover and mutation operators - Optimization problems using GA-discrete and continuous - Single objective and multi-objective problems - Procedures in evolutionary programming.

**UNIT V HYBRID CONTROL SCHEMES** 9

Fuzzification and rule base using ANN–Neuro fuzzy systems-ANFIS – Fuzzy Neuron - Optimization of membership function and rule base using Genetic Algorithm –Introduction to Support Vector Machine- Evolutionary Programming-Particle Swarm Optimization - Case study – Familiarization of NN, FLC and ANFIS Tool Box.

**TOTAL: 60 PERIODS**

**TEXT BOOKS:**


1. Laurene V. Fausett, "Fundamentals of Neural Networks: Architectures, Algorithms And Applications", Pearson Education. Wiley India, 2018.
2. Timothy J. Ross, "Fuzzy Logic with Engineering Applications" Wiley India, 2016. Zimmermann H.J. "Fuzzy set theory and its Applications" Springer international edition, 2017.
3. T. Ross, "Fuzzy Logic with Engineering Applications", Tata McGraw Hill, New Delhi, 2003.
4. Ethem Alpaydin, "Introduction to Machine Learning (Adaptive Computation and Machine Learning Series)", MIT Press, 2014.

Corinna Cortes and V. Vapnik, " Support - Vector Networks, Machine Learning " 1995.


**Mapping of Course Outcomes (COs) with Program Outcomes (POs) Program Specific Outcomes (PSOs)**

| COs | POs | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| CO1 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO2 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO3 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO4 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO5 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| | 3 | High | | | | 2 | Medium | | | | | 1 | Low | | |

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| Formative assessment | | | |
|---|---|---|---|
| Bloom's Level | Assessment Component | Marks | Total marks |
| Remember | Classroom or Online Quiz | 5 | |
| Understand | Class Presentation/Power point presentation | 5 | 15 |
| | Attendance | 5 | |

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| 20PPEE02 | Electromagnetic Field Computation and Modelling | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| Nature of Course | Professional Elective | | | | |
| Pre requisites | Basic of Electrmagnic Theroy | | | | |

**Course Objectives**

1. To refresh the fundamentals of Electromagnetic Field Theory.
2. To provide foundation in formulation and computation of Electromagnetic Fields using analytical and numerical methods.
3. To impart in-depth knowledge on Finite Element Method in solving Electromagnetic field problems.
4. To introduce the concept of mathematical modeling and design of electrical apparatus.

**Course Outcomes**

On successful completion of the course, students will be able to

| CO.No. | Course Outcome | Bloom's Level |
|---|---|---|
| CO1 | Understand the concepts of electromagnetic. | Understand |
| CO2 | To formulate the basic of FEM | Apply |
| CO3 | The concepts in the design of rotating machines | Apply |
| CO4 | To formulate the FEM method | Apply |
| CO5 | To formulate the use of the package | Apply |

**Course Contents:**

**UNIT I INTRODUCTION** 9

Review of basic field theory – Maxwell's equations – Constitutive relationships and Continuity equations – Laplace, Poisson and Helmholtz equation – principle of energy conversion – force/torque calculation.

**UNIT II BASIC SOLUTION METHODS FOR FIELD EQUATIONS** 9

Limitations of the conventional design procedure, need for the field analysis based design, problem definition, boundary conditions, solution by analytical methods-direct integration method – variable separable method – method of images, solution by numerical methods- Finite Difference Method.

**UNIT III FORMULATION OF FINITE ELEMENT METHOD (FEM)** 9

Variational Formulation – Energy minimization – Discretization – Shape functions –Stiffness matrix – 1D and 2D planar and axial symmetry problems.

**UNIT IV COMPUTATION OF BASIC QUANTITIES USING FEM PACKAGES** 9

Basic quantities – Energy stored in Electric Field – Capacitance – Magnetic Field – Linked Flux – Inductance – Force – Torque – Skin effect – Resistance.

**UNIT V DESIGN APPLICATIONS** 9

Design of Insulators – Cylindrical magnetic actuators – Transformers – Rotating machines

**TOTAL: 45 PERIODS**

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**TEXT BOOKS:**


1. Matthew. N.O. Sadiku, "Elements of Electromagnetics", Fourth Edition, Oxford University Press, First Indian Edition 2017
2. K.J.Binns, P.J.Lawrenson, C.W Trowbridge, "The analytical and numerical solution of Electric and magnetic fields", John Wiley & Sons, 2021.
3. Nicola Biyanchi , "Electrical Machine analysis using Finite Elements", Taylor and Francis Group, CRC Publishers, 2015.
4. Ethem Alpaydin, "Introduction to Machine Learning (Adaptive Computation and Machine Learning Series)", MIT Press, 2015.


**Mapping of Course Outcomes (COs) with Program Outcomes (POs) Program Specific Outcomes (PSOs)**

| COs | POs | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| CO1 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO2 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO3 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO4 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO5 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| | 3 | High | | | | 2 | Medium | | | | | 1 | Low | | |

| Formative assessment | | | |
|---|---|---|---|
| **Bloom's Level** | **Assessment Component** | **Marks** | **Total marks** |
| Remember | Classroom or Online Quiz | 5 | 15 |
| Understand | Class Presentation/Power point presentation | 5 | |
| | Attendance | 5 | |

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| 20PPEE03 | CONTROL SYSTEM DESIGN FOR POWER ELECTRONICS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| Nature of Course | Professional Elective | | | | |
| Pre requisites | Power Electronics | | | | |

**Course Objectives**

1. To explore conceptual bridges between the fields of Control Systems and Power Electronics
2. To Study Control theories and techniques relevant to the design of feedback controllers in Power Electronics

**Course Outcomes**

On successful completion of the course, students will be able to

| CO.No. | Course Outcome | Bloom's Level |
|---|---|---|
| CO1 | To understand an overview on modern linear and nonlinear control strategies for power electronics devices | Analyzing |
| CO2 | Model modern power electronic converters for industrial applications | Apply |
| CO3 | Design appropriate controllers for modern power electronics devices | Apply |
| CO4 | Analyze and control the linear parameters of power electronics | Analyzing |
| CO5 | Analyze and control the non linear parameters of power electronics | Analyzing |

**Course Contents:**

**UNIT I MODELLING OF DC-TO-DC POWER CONVERTERS** 9

Modelling of Buck Converter , Boost Converter ,Buck-Boost Converter, Cuk Converter ,Sepic Converter, Zeta Converter, Quadratic Buck Converter ,Double Buck-Boost Converter, Boost- Boost Converter General Mathematical Model for Power Electronics Devices

**UNIT II SLIDING MODE CONTROLLER DESIGN** 9

Variable Structure Systems. Single Switch Regulated Systems Sliding Surfaces, Accessibility of the Sliding Surface Sliding Mode Control Implementation of Boost Converter ,Buck-Boost Converter, Cuk Converter ,Sepic Converter, Zeta Converter, Quadratic Buck Converter ,Double Buck-Boost Converter, Boost-Boost Converter.

**UNIT III APPROXIMATE LINEARIZATION CONTROLLER DESIGN** 9

Linear Feedback Control, Pole Placement by Full State Feedback , Pole Placement Based on Observer Design ,Reduced Order Observers , Generalized Proportional Integral Controllers, Passivity Based Control , Sliding Mode Control Implementation of Buck Converter , Boost Converter ,Buck-Boost Converter

**UNIT IV NONLINEAR CONTROLLER DESIGN** 9

Feedback Linearization Isidori's Canonical Form ,Input-Output Feedback Linearization ,State Feedback Linearization,Passivity Based Control , Full Order Observers , Reduced.

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**UNIT V PREDICTIVE CONTROL OF POWER CONVERTERS**

Basic Concepts, Theory, and Methods, Application of Predictive Control in Power Electronics, AC-D
AC Converter System, Faults and Diagnosis Systems in Power Converters.

**TOTAL: 45 PERIODS**

**TEXT BOOKS:**


1. HeberttSira-Ramlrez PhD, Ramón Silva-Ortigoza, "Control Design Techniques in Power Electronics Devices", Springer 2018
2. Mahesh Patil, PankajRodey, "Control Systems for Power Electronics: A Practical Guide", Springer India, 2015.
3. Blaabjerg José Rodrlguez, "Advanced and Intelligent Control in Power Electronics and Drives" , Springer, 2014.


**Mapping of Course Outcomes (COs) with Program Outcomes (POs) Program Specific Outcomes (PSOs)**

| COs | POs | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| CO1 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO2 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO3 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO4 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO5 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| | 3 | High | | | | 2 | Medium | | | | | 1 | Low | | |

| Formative assessment | | | |
|---|---|---|---|
| **Bloom's Level** | **Assessment Component** | **Marks** | **Total marks** |
| Remember | Classroom or Online Quiz | 5 | 15 |
| Understand | Class Presentation/Power point presentation | 5 | |
| | Attendance | 5 | |

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## LIST OF PROFESSIONAL ELECTIVES-II
## SEMESTER-I

| 20PPEE11 | Analog and Digital Controllers | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| Nature of Course | Professional Electives | | | | |
| Pre requisites | control system and converter control methodologies | | | | |

**Course Objectives**

1. To provide a overview of the control system and converter control methodologies
2. To provide an insight to the analog controllers generally used in practice
3. To introduce Embedded Processers for Digital Control
4. To study on the driving techniques, isolation requirements, signal conditioning and protection methods
5. To provide a Case Study by implementing an analog and a digital controller on a converter

**Course Outcomes**

On successful completion of the course, students will be able to

| CO.No. | Course Outcome | Bloom's Level |
|---|---|---|
| CO1 | To understand an overview on modern linear and nonlinear control strategies for power electronics devices | Analyzing |
| CO2 | To model modern power electronic converters for industrial applications | Apply |
| CO3 | Design appropriate controllers for modern power electronics devices. | Apply |
| CO4 | Analyze and control the non linear parameters of power electronics | Analyzing |
| CO5 | Apply and control the non linear parameters of power electronics | Apply |

**Course Contents:**

**UNIT I CONTROL SYSTEM – OVERVIEW** 9

Feedback and Feed-forward control, Right Half Plane Zero, Gain margin and Phase Margin, Stability, Analysis and Transfer function of PI and PID controllers and its effects. Voltage mode control, Peak Current mode Control, Average Current mode Control for Converters – Need, advantages and disadvantages.

**UNIT II ANALOG CONTROLLERS** 9

Major components of a controller – Op-Amp based PI and PID controller – Proportional, Integral and Differential gains in terms of Resistance and Capacitance, Error Amplifiers, PWM generator using Ramp or Triangular generator and comparator, and Driver, Voltage mode controller design using UC3524, Peak Current mode controller design using UC3842, Average Current mode controller design using UC3854.

**UNIT III DIGITAL CONTROLLERS** 9

Micro Controllers and Digital Signal Controllers for Converter Control Application, Interface Modules for Converter Control – A/D, Capture, Compare and PWM, Analog Comparators for instantaneous over current detection, Interrupts, Discrete PI and PID equations, Algorithm for PI and PID implementation, Example Code for PWM generation. Converter , Boost Converter ,Buck-Boost Converter.

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**UNIT IV SIGNAL CONDITIONING, DRIVER, ISOLATION AND PROTECTION** 9

Voltage feedback sensing circuits, Hall effect sensors and Shunts for current feedback sensing, Low offset Op-Amps for signal conditioning, Single and dual supply op-amps, Totem pole drivers, Need for isolated drivers, Optically isolated drivers, low side drivers, high side drivers with bootstrap power supply, Vce sat sensing, CT based Device current sensing and pulse blocking.

**UNIT V CONTROLLER IMPLEMENTATION** 9

Analog and Digital Controller Design for Buck Converter – Power circuit transfer function and bode plot, PI controller bode plot, Combined bode plot with required Gain and Phase margins, Implementation of Analog controller and Digital controller.

**TOTAL: 45 PERIODS**

**REFERENCE BOOKS:**


1. I.J. Nagrath and M. Gopal, "Control Systems Engineering", New Age International Publishers,2016.
2. TI Application notes, Reference Manuals and Data Sheets.Agilent Data Sheets,2017.
3. Microchip Application notes, Reference Manuals and Data Sheets.


| Mapping of Course Outcomes (COs) with Program Outcomes (POs) Program Specific Outcomes (PSOs) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | POs | | | | | | | | | | | | PSOs | | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| CO1 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO2 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO3 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO4 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO5 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| | 3 | High | | | | 2 | Medium | | | | | 1 | Low | | |

| Formative assessment | | | |
|---|---|---|---|
| Bloom's Level | Assessment Component | Marks | Total marks |
| Remember | Classroom or Online Quiz | 5 | 15 |
| Understand | Class Presentation/Power point presentation | 5 | |
| | Attendance | 5 | |

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| 20PPEE12 | FLEXIBLE AC TRANSMISSION SYSTEMS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| Nature of Course | Fundamental Core | | | | |
| Pre requisites | Modeling of Electrical Machines | | | | |

**Course Objectives**

1. To emphasis the need for FACTS controllers.
2. To learn the characteristics, applications
3. modelling of series and shunt FACTS controllers.
4. To analyze the interaction of different FACTS controller
5. To analyze the perform control coordination

**Course Outcomes**

On successful completion of the course, students will be able to

| CO.No. | Course Outcome | Bloom's Level |
|---|---|---|
| CO1 | understand the operation of the compensator | Understand |
| CO2 | understand the various emerging Facts controllers | Understand |
| CO3 | To know about the genetic algorithm | Understand |
| CO4 | Facts its applications in power system. | Apply |
| CO5 | Facts controller coordination. | Understand |

**Course Contents:**

**UNIT I INTRODUCTION** 9

Review of basics of power transmission networks-control of power flow in AC transmission line Analysis of uncompensated AC Transmission line- Passive reactive power compensation: Effect of series and shunt compensation at the mid-point of the line on power transfer- Need for FACTS controllers- types of FACTS controllers.

**UNIT II STATIC VAR COMPENSATOR (SVC)** 9

Configuration of SVC- voltage regulation by SVC- Modelling of SVC for load flow analysis Modelling of SVC for stability studies-Design of SVC to regulate the mid-point voltage of a SMIB system-Applications: transient stability enhancement and power oscillation damping of SMIB system with SVC connected at the mid-point of the line.

**UNIT III THYRISTOR AND GTO THYRISTOR CONTROLLED SERIES CAPACITORS (TCSC and GCSC)** 9

Concepts of Controlled Series Compensation – Operation of TCSC and GCSC- Analysis of TCSC-GCSC – Modelling of TCSC and GCSC for load flow studies- modeling TCSC and GCSC for stability studied- Applications of TCSC and GCSC.

**UNIT IV VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS** 9

Static synchronous compensator(STATCOM)- Static synchronous series compensator(SSSC)-Operation of STATCOM and SSSC-Power flow control with STATCOM and SSSC- Modelling of STATCOM and SSSC for power flow and transient stability studies –operation of Unified and Interline power flow controllers(UPFC and IPFC)- Modelling of UPFC and IPFC for load flow and transien stability studies – Applications.

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**UNIT V CONTROLLERS AND THEIR COORDINATION** **TOTAL: 45 PERIOD**

FACTS Controller interactions – SVC–SVC interaction - co-ordination of multiple controllers using linear control techniques – Quantitative treatment of control coordination.

**REFERENCE BOOKS:**


1. A.T.John, "Flexible AC Transmission System", Institution of Electrical and Electronic Engineers (IEEE), 2017.
2. NarainG.Hingorani, Laszio. Gyugyl, "Understanding FACTS Concepts and Technology of Flexible AC Transmission System", Standard Publishers, Delhi 2016.
3. V. K.Sood, "HVDC and FACTS controllers- Applications of Static Converters in Power System", 2014.
4. Mohan Mathur, R., Rajiv. K. Varma, "Thyristor – Based Facts Controllers for Electrical Transmission Systems", IEEE press and John Wiley & Sons, Inc, 2018.
5. K.R.Padiyar," FACTS Controllers in Power Transmission and Distribution", New Age International(P) Ltd., Publishers New Delhi, Reprint 2019.


**Mapping of Course Outcomes (COs) with Program Outcomes (POs) Program Specific Outcomes (PSOs)**

| COs | POs | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| CO1 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO2 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO3 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO4 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO5 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| | 3 | High | | | | 2 | Medium | | | | | 1 | Low | | |

| Formative assessment | | | |
|---|---|---|---|
| **Bloom's Level** | **Assessment Component** | **Marks** | **Total marks** |
| Remember | Classroom or Online Quiz | 5 | 15 |
| Understand | Class Presentation/Power point presentation | 5 | |
| | Attendance | 5 | |

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| 20PPEE13 | DISTRIBUTED GENERATION AND MICROGRID | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| Nature of Course | Professional Elective | | | | |
| Pre requisites | distributed generation | | | | |

**Course Objectives:**

1. To illustrate the concept of distributed generation
2. To analyze the impact of grid integration.
3. To study concept of Micro grid and its configuration

**Course Outcomes**

**On successful completion of the course, students will be able to**

| CO.No. | Course Outcome | Bloom's Level |
|---|---|---|
| CO1 | Learners will attain knowledge on the various schemes of conventional and nonconventional power generation. | Analyzing |
| CO2 | Learners will have knowledge on the topologies and energy sources of distributed generation. | Analyzing |
| CO3 | Learners will understand the fundamental concept of Microgrid | Understand |

**Course Contents:**

**UNIT I INTRODUCTION** 9

Conventional power generation: advantages and disadvantages, Energy crises, Non- conventional energy (NCE) resources: review of Solar PV, Wind Energy systems, Fuel Cells, micro-turbines, biomass, and tidal sources.

**UNIT II DISTRIBUTED GENERATIONS (DG)** 9

Concept of distributed generations, topologies, selection of sources, regulatory standards/ framework, Standards for interconnecting Distributed resources to electric power systems: IEEE 1547. DG installation classes, security issues in DG implementations. Energy storage elements: Batteries, ultra-capacitors, flywheels. Captive power plants

**UNIT III IMPACT OF GRID INTEGRATION** 9

Requirements for grid interconnection, limits on operational parameters,: voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues. Impact of grid integration with NCE sources on existing power system: reliability, stability and power quality issues.

**UNIT IV BASICS OF A MICROGRID** 9

Concept and definition of microgrid, microgrid drivers and benefits, review of sources of microgrids, typical structure and configuration of a microgrid, AC and DC microgrids, Power Electronics interfaces in DC and AC microgrids

**UNIT V CONTROL AND OPERATION OF MICROGRID** 9

Modes of operation and control of microgrid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques, microgrid communication infrastructure, Power quality issues in microgrids, regulatory standards, Microgrid economics, Introduction to smart microgrids.

**TOTAL : 45 PERIODS**

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**REFERENCES**


1 Amirnaser Yezdani, and Reza Iravani, "Voltage Source Converters in Power Systems: Modeling, Control and Applications", IEEE John Wiley Publications, 2015.
2 DorinNeacsu, "Power Switching Converters: Medium and High Power", CRC Press, Taylor & Francis, 2016
3 Chetan Singh Solanki, "Solar Photo Voltaics", PHI learning Pvt. Ltd., New Delhi,2019
4 J.F. Manwell, J.G. McGowan "Wind Energy Explained, theory design and applications", Wiley publication 2017.
5 D. D. Hall and R. P. Grover, "Biomass Regenerable Energy", John Wiley, New York, 2017.
6 John Twidell and Tony Weir, "Renewable Energy Resources" Tyalor and Francis Publications, Second edition 2016.


**Mapping of Course Outcomes (COs) with Program Outcomes (POs) Program Specific Outcomes (PSOs)**

| COs | POs | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| CO1 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO2 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO3 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO4 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO5 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| | 3 | High | | | | 2 | Medium | | | | | 1 | Low | | |

**Formative assessment**

| Bloom's Level | Assessment Component | Marks | Total marks |
|---|---|---|---|
| Remember | Classroom or Online Quiz | 5 | 15 |
| Understand | Class Presentation/Power point presentation | 5 | |
| | Attendance | 5 | |

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## LIST OF PROFESSIONAL ELECTIVES-III
## SEMESTER-II

| 20PPEE21 | MODERN RECTIFIERS AND RESONANT CONVERTERS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| Nature of Course | Professional Elective | | | | |
| Pre requisites | Basic Power system and Power Electronics | | | | |

**Course Objectives**

1. To gain knowledge about the harmonics standards and operation of rectifiers in CCM & DCM.
2. To analyze and design power factor correction rectifiers for UPS applications.
3. To know the operation of resonant converters for SMPS applications.
4. To carry out dynamic analysis of DC- DC Converters
5. To introduce the source current shaping methods for rectifiers

**Course Outcomes**

On successful completion of the course, students will be able to

| CO.No. | Course Outcome | Bloom's Level |
|---|---|---|
| CO1 | To concept of various types of rectifiers | Apply |
| CO2 | Simulate and design the operation of resonant converter and its importance. | Apply |
| CO3 | Identify the importance of linear system, state space model, PI controller. | Understand |
| CO4 | Design the DC power supplies using advanced techniques | Apply |
| CO5 | Understand the standards for supply current harmonics and it significance | Understand |

**Course Contents:**

**UNIT I POWER SYSTEM HARMONICS & LINE COMMUTATED RECTIFIERS** 9

Average power-RMS value of waveform–Effect of Power factor-. current and voltage harmonics – Effect of source and load impedance - AC line current harmonic standards IEC1000-IEEE 519-CCM and DCM operation of single phase full wave rectifier- Behaviour of full wave rectifier for large and small values of capacitance - CCM and DCM operation of three phase full wave rectifier- 12 pulse converters - Harmonic trap filters.

**UNIT II PULSE WIDTH MODULATED RECTIFIERS** 9

Properties of Ideal single phase rectifiers-Realization of nearly ideal rectifier-. Single-phase converter systems incorporating ideal rectifiers - Losses and efficiency in CCM high quality rectifiers -single-phase PWM rectifier -PWM concepts - device selection for rectifiers - IGBT based PWM rectifier, comparison with SCR based converters with respect to harmonic content -applications of rectifiers.

**UNIT III RESONANT CONVERTERS** 9

Soft Switching - classification of resonant converters - Quasi resonant converters- basics of ZVS and ZCS- half wave and full wave operation (qualitative treatment) - multi resonant converters - operation and analysis of ZVS and ZCS multi resonant converter - zero voltage transition PWM converters -zero current transition PWM converters

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**UNIT IV DYNAMIC ANALYSIS OF SWITCHING CONVERTERS**

Review of linear system analysis-State Space Averaging-Basic State Space Average Model- State Space Averaged model for an ideal Buck Converter, ideal Boost Converter, ideal Buck Boost Converter and an ideal Cuk Converter. Pulse Width modulation - Voltage Mode PWM Scheme - Current Mode PWM Scheme - design of PI controller.

**UNIT V SOURCE CURRENT SHAPING OF RECTIFIERS**

Need for current shaping - power factor - functions of current shaper - input current shaping methods - passive shaping methods -input inductor filter - resonant input filter - active methods - boost rectifier employing peak current control - average current control - Hysteresis control- Nonlinear carrier control

**TOTAL: 45 PERIODS**

**REFERENCE BOOKS:**


1. Robert W. Erickson and Dragon Maksimovic, "Fundamentals of Power Electronics", Second Edition, Springer science and Business media, 2016.
2. William Shepherd and Li zhang, "Power Converters Circuits", MarceldEkkerin,C, 2015.
3. Simon Ang and Alejandro Oliva, "Power Switching Converters", Taylor & Francis Group, 2016.
4. Andrzej M. Trzynadlowski, " Introduction To Modern Power Electronics", John Wiley & Sons, 2016.
5. Marian.K.Kazimierczuk and DariuszCzarkowski, "Resonant Power Converters", John Wiley & Sons limited, 2016.
6. Keng C .Wu, "Switch Mode Power Converters – Design and Analysis" Elseveir academic press, 2016.
7. Abraham I.Pressman, Keith Billings and Taylor Morey, " Switching Power Supply Design" McGraw-Hill ,2019
8. V.Ramanarayanan, "Course Material on Switched Mode Power Conversion" IISC, Banglore, 2017.
9. Christophe P. Basso, Switch-Mode Power Supplies, McGraw-Hill ,2014.


**Mapping of Course Outcomes (COs) with Program Outcomes (POs) Program Specific Outcomes (PSOs)**

| COs | POs | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| CO1 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO2 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO3 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO4 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO5 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| | 3 | High | | | | 2 | Medium | | | | | 1 | Low | | |

**Formative assessment**

| Bloom's Level | Assessment Component | Marks | Total marks |
|---|---|---|---|
| Remember | Classroom or Online Quiz | 5 | 15 |
| Understand | Class Presentation/Power point presentation | 5 | |
| | Attendance | 5 | |

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| 20PPEE22 | COMPUTER AIDED SIMULATION AND DESIGN OF POWER ELECTRONICS SYSTEM | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| Nature of Course | Professional Elective | | | | |
| Pre requisites | Basic Power system and Power Electronics | | | | |

**Course Objectives**

1. To gain knowledge about the model/simulate various types of power semiconductors, power electronics converters.
2. To analyze and design power electronics converters their role in monitoring, controlling and conversion

**Course Outcomes**

On successful completion of the course, students will be able to

| CO.No. | Course Outcome | Bloom's Level |
|---|---|---|
| CO1 | choose suitable software package for power electronic circuits analysis | Applying |
| CO2 | understand the principle of controlled devices and model various semiconductor devices in Pspice environment | Understand |
| CO3 | Apply the simulation model for Rectifier in SIMULINK and PSIM environment. | Applying |
| CO4 | Apply the simulation model for chopper in SIMULINK and PSIM environment. | Applying |
| CO5 | Apply the simulation model for inverter in SIMULINK and PSIM environment | Applying |

**Course Contents:**

**UNIT I INTRODUCTION** 9

Review of power electronic software simulation tools, PSPICE, PSIM- Importance of simulation – Challenges in simulation - PSpice : File formats - Description of circuit elements - Circuit description – Output variables - Dot commands. PSIM : elements of psim - power circuit and control circuit component – circuit schematic design using simcad - simcoupler – Magnet plugins – waveform process using simview. MATLAB and Simulink : Toolboxes of MATLAB - Programming and file processing in MATLAB – Model definition and model analysis using SIMULINK - S-Functions - Converting S Functions to blocks.

**UNIT II MODELING AND SIMULATION OF POWER ELECTRONIC DEVICES** 9

Model,Statement,Characteristics and Parameters of Diode , BJT,MOSFET,IGBT and GTO using PSpice , PSIM and MATLAB.

**UNIT III SIMULATION OF AC/DC CONVERTERS** 9

Diode rectifiers -Controlled rectifiers- Single-Phase Half-Wave Controlled Rectifier -Single-Phase Full-Wave Controlled Rectifier-Three-Phase Full-Wave Controlled Rectifier Simulation Using PSPICE, PSIM and Simscape MATLAB Analysis.

**UNIT IV SIMULATION OF DC/DC CONVERTERS** 9

DC Switch – BJT and MOSFET based Choppers buck and boost Using PSPICE, PSIM and Sims cape MATLAB Analysis

**UNIT V SIMULATION OF DC/AC CONVERTERS** 9

Pulse-Width-Modulated Inverters - Single-Phase Half-Bridge and Full-Bridge Inverter-Single-Phase Full-

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Bridge Inverter with PWM and SPWM -Three-Phase Bridge Inverter using Electrical Circuit Simulat
Using PSPICE, PSIM and Simscape MATLAB Analysis.

**TOTAL: 45 PERIO**

**REFERENCE BOOKS:**


1. Muhammad H. Rashid, "SPICE for Power Electronics and Electric Power", 3rd Edition, Taylor
   Francis, 2005.
2. 2. M. Godoy Simoes, Felix A. Farret, "Modeling Power Electronics and Interfacing Energ
   Conversion Systems", IEEE press, Wiley publications,2017 .
3. 3. Partha S. Mallick, "MATLAB and SIMULINK: Introduction to Applications", 4th Edition,Scitec
   Publications (India), 2011.


**Mapping of Course Outcomes (COs) with Program Outcomes (POs) Program Specific Outcomes (PSOs)**

| COs | POs | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| CO1 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO2 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO3 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO4 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO5 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| | 3 | High | | | | 2 | Medium | | | | | 1 | Low | | |

| Formative assessment | | | |
|---|---|---|---|
| **Bloom's Level** | **Assessment Component** | **Marks** | **Total marks** |
| Remember | Classroom or Online Quiz | 5 | 15 |
| Understand | Class Presentation/Power point presentation | 5 | |
| | Attendance | 5 | |

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| 20PPEE23 | Field Programmable Gate Array DESIGN | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| Nature of Course | Professional Elective | | | | |
| Pre requisites | Fundamentals of multiprocessor and multicomputer systems & Architecture | | | | |

**Course Objectives**

1. To study the design flow of different types of ASIC.
2. To familiarize the different types of programming technologies and logic devices.
3. To learn the architecture of different types of FPGA.
4. To gain knowledge about partitioning, floor planning, placement and routing including circuit extraction of ASIC.
5. To analyse the synthesis, Simulation and testing of systems.

**Course Outcomes**

On successful completion of the course, students will be able to

| CO.No. | Course Outcome | Bloom's Level |
|---|---|---|
| CO1 | An ability to understand the operations of multiprocessor and multicomputer systems. | Analyzing |
| CO2 | To understand the various advanced processor technology, pipelining and scalable architectures. | Understand |
| CO3 | To know the working of superscalar pipeline, cache memory organization. | Analyzing |
| CO4 | To understand the principles of multithreading, multithread architecture, static and dynamic data flow. | Understand |
| CO5 | Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded systems design. | Apply |

**Course Contents:**

**UNIT I OVERVIEW OF ASIC AND PLD** 9

Types of ASICs - Design flow – CAD tools used in ASIC Design – Programming Technologies: Antifuse – static RAM – EPROM and EEPROM technology, Programmable Logic Devices: ROMs and EPROMs – PLA –PAL. Gate Arrays – CPLDs and FPGAs

**UNIT II ASIC PHYSICAL DESIGN** 9

System partition -partitioning - partitioning methods – interconnect delay models and measurement of delay - floor planning - placement – Routing: global routing - detailed routing - special routing - circuit extraction – DRC.

**UNIT III LOGIC SYNTHESIS, SIMULATION AND TESTING** 9

Design systems - Logic Synthesis - Half gate ASIC -Schematic entry - Low level design language -PLA tools -EDIF- CFI design representation. Verilog and logic synthesis -VHDL and logic synthesis - types of simulation -boundary scan test - fault simulation - automatic test pattern generation.

**UNIT IV FPGA** 9

Field Programmable gate arrays- Logic blocks, routing architecture, Design flow technology -mapping for FPGAs, Xilinx XC4000 - ALTERA's FLEX 8000/10000, ACTEL's ACT-1,2,3 and their speed performance Case studies: Altera MAX 5000 and 7000 - Altera MAX 9000 – Spartan II and Virtex II FPGAs - Apex and Cyclone FPGAs

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**UNIT V SOC DESIGN** 9

Design Methodologies – Processes and Flows - Embedded software development for SOC –Techniques for SOC Testing – Configurable SOC – Hardware / Software co design Case studies: Digital camera, Bluetooth radio / modem, SDRAM and USB. **TOTAL: 45 PERIODS**

**REFERENCES:**


1. M.J.S .Smith, "Application Specific Integrated Circuits, Addison -Wesley Longman Inc., 2017.
2. S. Trimberger, Field Programmable Gate Array Technology, Edr, Kluwer Academic Publications, 1994.
3. John V.Oldfield, Richard C Dore, Field Programmable Gate Arrays, Wiley Publications 1995.
4. P.K.Chan & S. Mourad, Digital Design Using Field Programmable Gate Array, Prentice Hall, 2015.
5. Parag.K.Lala, Digital System Design using Programmable Logic Devices , BSP, 2013.
6. S. Brown, R. Francis, J. Rose, Z. Vransic, Field Programmable Gate Array, Kluwer Pubin, 2018.


| Mapping of Course Outcomes (COs) with Program Outcomes (POs) Program Specific Outcomes (PSOs) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | POs | | | | | | | | | | | | PSOs | | |
| COs | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| CO1 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO2 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO3 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO4 | 3 | 3 | 2 | | | | | | | | | | 3 | 2 | 3 |
| CO5 | 3 | 3 | 2 | | | . | | | | | | | 3 | 2 | 3 |
| | 3 | High | | | | 2 | Medium | | | | | 1 | Low | | |

| Formative assessment | | | |
|---|---|---|---|
| Bloom's Level | Assessment Component | Marks | Total marks |
| Remember | Classroom or Online Quiz | 5 | 15 |
| Understand | Class Presentation/Power point presentation | 5 | |
| | Attendance | 5 | |

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## LIST OF PROFESSIONAL ELECTIVES-IV
## SEMESTER-II

| 20PPEE31 | HIGH VOLTAGE DIRECT CURRENT TRANSMISSION | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| Nature of Course | Professional Elective | | | | |
| Pre requisites | Power System | | | | |

**Course Objectives**

1. To impart knowledge on operation, modelling and control of HVDC link.
2. To perform steady state analysis of AC/DC system.
3. To expose various HVDC simulators.

**Course Outcomes**

On successful completion of the course, students will be able to

| CO.No. | Course Outcome | Bloom's Level |
|---|---|---|
| CO1 | Analyze the synthesis, power transmission | Analyzing |
| CO2 | Apply different high performance control system | Apply |
| CO3 | Design multiple terminals and testing. | Apply |
| CO4 | Design the Power flow analysis. | Apply |
| CO5 | Discuss the design HVDC | Analyzing |

**Course Contents:**

**UNIT I DC POWER TRANSMISSION TECHNOLOGY** 9

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

**UNIT II THYRISTOR BASED HVDC CONVERTERS AND HVDC SYSTEM CONTROL** 9

Pulse number, choice of converter configuration – Simplified analysis of Graetz circuit - Converter bridge characteristics – characteristics of a twelve pulse converter- detailed analysis of converters. 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-Valve tests.

**UNIT III MULTITERMINAL DC SYSTEMS** 9

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** 9

Per unit system for DC Quantities - Modelling of DC links - Solution of DC load flow - Solution of AC-DC power flow – Unified, Sequential and Substitution of power injection method

**UNIT V SIMULATION OF HVDC SYSTEMS** 9

Introduction – DC LINK Modelling , Converter Modeling and State Space Analysis , Philosophy and tools – HVDC system simulation, Online and OFF line simulators — Dynamic interactions between DC and AC systems.

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TOTAL: 45 PERIOD

REFERENCES


1 P. Kundur, "Power System Stability and Control", McGraw-Hill, 2017.
2 K.R.Padiyar, , "HVDC Power Transmission Systems", New Age International (P) Ltd., New Delhi, 2012
3 J.Arrillaga, , "High Voltage Direct Current Transmission", Peter Pregrinus, London, 2017.
4 Erich Uhlmann, " Power Transmission by Direct Current", BS Publications, 2014.
5 V.K.Sood,HVDC and FACTS controllers – Applications of Static Converters in Power System, , Kluwer Academic Publishers APRIL 2014.


**Mapping of Course Outcomes (COs) with Program Outcomes (POs) Program Specific Outcomes (PSOs)**

| COs | POs | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| CO1 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| CO2 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| CO3 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| CO4 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| CO5 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| | 3 | High | | | | 2 | Medium | | | | | 1 | Low | | |

| Formative assessment | | | |
|---|---|---|---|
| **Bloom's Level** | **Assessment Component** | **Marks** | **Total marks** |
| Remember | Classroom or Online Quiz | 5 | 15 |
| Understand | Class Presentation/Power point presentation | 5 | |
| | Attendance | 5 | |

| Summative assessment based on Continuous and End Semester Examination | | |
|---|---|---|
| **Bloom's Level** | **Internal Assessment [50 marks]** | **End Semester Examination [50 marks]** |
| Remember | 10 | 10 |
| Understand | 20 | 20 |
| Apply | 40 | 40 |
| Analyze | 30 | 30 |
| Evaluate | - | - |
| Create | - | - |

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| 20PPEE32 | SOLAR AND ENERGY STORAGE SYSTEMS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| Nature of Course | Professional Elective | | | | |
| Pre requisites | Fundamentals system for Solar and battery | | | | |

**Course Objectives**

1. To understand the fundamentals of solar modules.
2. To Study about PV system design and their applications
3. To Deal with grid connected PV systems
4. To Discuss about different energy storage systems

**Course Outcomes**

On successful completion of the course, students will be able to

| CO.No. | Course Outcome | Bloom's Level |
|---|---|---|
| CO1 | Students will develop more understanding on solar energy storage stems | Understand |
| CO2 | Students will develop basic knowledge on standalone PV system | Understand |
| CO3 | Students will understand the issues in grid connected PV systems | Understand |
| CO4 | Students will study about the modeling of different energy storage systems and their performances | Apply |
| CO5 | Students will attain more on different applications of solar energy | Apply |

**Course Contents:**

**UNIT I INTRODUCTION** 9

Characteristics of sunlight – semiconductors and P-N junctions –behavior of solar cells – cell properties – PV cell interconnection

**UNIT II STAND ALONE PV SYSTEM** 9

Solar modules – storage systems – power conditioning and regulation - MPPT- protection – stand alone PV systems design – sizing

**UNIT III GRID CONNECTED PV SYSTEMS** 9

PV systems in buildings – design issues for central power stations – safety – Economic aspect – Efficiency and performance - International PV programs

**UNIT IV ENERGY STORAGE SYSTEMS** 9

Impact of intermittent generation – Battery energy storage – solar thermal energy storage – pumped hydroelectric energy storage

**UNIT V APPLICATIONS** 9

Water pumping – battery chargers – solar car – direct-drive applications –Space – Telecommunications.

**TOTAL: 45 PERIODS**

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**TEXT BOOKS:**


1. Solanki C.S., "Solar Photovoltaics: Fundamentals, Technologies And Applications", PHI Learning Pvt. Ltd.,2015.
2. Stuart R.Wenham, Martin A.Green, Muriel E. Watt and Richard Corkish, "Applied Photovoltaics" 2017,Earthscan, UK.
3. Eduardo Lorenzo G. Araujo, "Solar electricity engineering of photovoltaic systems" Progensa,2016.
4. Frank S. Barnes & Jonah G. Levine, "Large Energy storage Systems Handbook", CRC Press, 2017.
4. McNeils, Frenkel, Desai, "Solar & Wind Energy Technologies", Wiley Eastern, 2016.
5. S.P. Sukhatme , "Solar Energy", Tata McGraw Hill,2017.


| Mapping of Course Outcomes (COs) with Program Outcomes (POs) Program Specific Outcomes (PSOs) | POs | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| CO1 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| CO2 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| CO3 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| CO4 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| CO5 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| | 3 | High | | | | 2 | Medium | | | | | 1 | Low | | |

| Formative assessment | | | |
|---|---|---|---|
| Bloom's Level | Assessment Component | Marks | Total marks |
| Remember | Classroom or Online Quiz | 5 | 15 |
| Understand | Class Presentation/Power point presentation | 5 | |
| | Attendance | 5 | |

| Summative assessment based on Continuous and End Semester Examination | | |
|---|---|---|
| Bloom's Level | Internal Assessment [50 marks] | End Semester Examination [50 marks] |
| Remember | 10 | 10 |
| Understand | 20 | 20 |
| Apply | 40 | 40 |
| Analyze | 30 | 30 |
| Evaluate | - | - |
| Create | - | - |

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| 20PPEE33 | NON LINEAR CONTROL | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| Nature of Course | Professional Elective | | | | |
| Pre requisites | Control System | | | | |

**Course Objectives**

1. To impart knowledge on phase plane analysis of non-linear systems.
2. To educate on representing systems in state variable form
3. To educate on stability analysis of systems using Lyapunov's theory.
4. To educate on stability analysis of systems using Lyapunov's theory.
5. To introduce the concept of sliding mode control.

**Course Outcomes**

On successful completion of the course, students will be able to

| CO.No. | Course Outcome | Bloom's Level |
|---|---|---|
| CO1 | Analyze the synthesis, Simulation and testing of systems. | Analyzing |
| CO2 | Understand the concepts of non-linear control system. | Understand |
| CO3 | Analyze the stability of the system | Analyzing |
| CO4 | Illustrate the sliding mode control | Analyzing |
| CO5 | Illustrate the implementation in MATLAB. | Apply |

**Course Contents:**

**UNIT I PHASE PLANE ANALYSIS** 9

Concepts of phase plane analysis- Phase portraits- singular points- Symmetry in phase plane portraits- Constructing Phase Portraits- Phase plane Analysis of Linear and Nonlinear Systems- Existence of Limit Cycles. simulation of phase portraits in matlab.

**UNIT II DESCRIBING FUNCTION** 9

Describing Function Fundamentals-Definitions-Assumptions-Computing Describing Functions- Common Nonlinearities and its Describing Functions-Nyquist Criterion and its Extension- Existence of Limit Cycles-Stability of limit Cycles. simulation of limit cycles in matlab.

**UNIT III LYAPUNOV THEORY** 9

Nonlinear Systems and Equilibrium Points-Concepts of Stability-Linearization and Local Stability-Lyapunov's Direct Method-Positive definite Functions and Lyapunov Functions-Equilibrium Point Theorems-Invariant Set Theorems-LTI System Analysis based on Lyapunov's Direct Method-Krasovski's Method-Variable Gradient Method-Physically – Control Design based on Lyapunov's Direct Method.

**UNIT IV FEEDBACK LINEARIZATION** 9

Feedback Linearization and the Canonical Form-Mathematical Tools-Input-State Linearization of SISO Systems- input-Output Linearization of SISO Systems-Generating a Linear Input-Output Relation- Normal Forms-The Zero-Dynamics-Stabilization and Tracking-Inverse Dynamics and Non- Minimum- Phase Systems-Feedback Linearization of MIMO Systems Zero-Dynamics and Control Design. Simulation of tracking problems in matlab.

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**UNIT V SLIDING MODE CONTROL** 9

Sliding Surfaces- Continuous approximations of Switching Control laws-The Modeling/Performance Trade-Offs- MIMO Systems. simulation of sliding mode controller in matlab. **TOTAL : 45 PERIODS**

**TEXT BOOKS:**


1. J A E Slotine and W Li, Applied Nonlinear control, PHI, 2014.
2. K. P. Mohandas, Modern Control Engineering, Sanguine, India, 2016.
   Hasan Khalil, "Nonlinear systems and control", Prentice Hall.
3. S H Zak, "Systems and control", Oxford University Press, 2013.
4. Torkel Glad and Lennart Ljung, "Control Theory – Multivariable and Nonlinear Methods",Taylor& Francis, 2012.
5. G. J. Thaler, "Automatic control systems", Jaico publishers, 2016.


**Mapping of Course Outcomes (COs) with Program Outcomes (POs) Program Specific Outcomes (PSOs)**

| COs | POs | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| CO1 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| CO2 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| CO3 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| CO4 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| CO5 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| | 3 | High | | | | 2 | Medium | | | | | 1 | Low | | |

| Formative assessment | | | |
|---|---|---|---|
| Bloom's Level | Assessment Component | Marks | Total marks |
| Remember | Classroom or Online Quiz | 5 | 15 |
| Understand | Class Presentation/Power point presentation | 5 | |
| | Attendance | 5 | |

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| Summative assessment based on Continuous and End Semester Examination | | |
|---|---|---|
| Bloom's Level | Internal Assessment [50 marks] | End Semester Examination [50 marks] |
| Remember | 10 | 10 |
| Understand | 20 | 20 |
| Apply | 40 | 40 |
| Analyze | 30 | 30 |
| Evaluate | - | - |
| Create | - | - |

Passed in Board of Studies Meeting (09.10.2021)

Approved in Academic Council Meeting (11.10.2021)

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| 20PPEE34 | ELECTRIC VEHICLES AND POWER MANAGEMENT | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| Nature of Course | Professional Elective | | | | |
| Pre requisites | Power Management System | | | | |

**Course Objectives**

1. To understand the concept of electrical vehicles
2. To understand the concept of the operations
3. To understand the need for energy storage in hybrid vehicles
4. To provide knowledge about various possible energy storage technologies
5. Learners will understand the operation of Electric vehicles and various energy storage technologies for electrical vehicles

**Course Outcomes**

On successful completion of the course, students will be able to

| CO.No. | Course Outcome | Bloom's Level |
|---|---|---|
| CO1 | Learners will understand the operation of Electric vehicles. | Understand |
| CO2 | Learners will understand the operation various energy storage technologies for electrical vehicles | Understand |
| CO3 | Learners will understand the used in electrical vehicles | Understand |
| CO4 | Design the electrical vehicles | Apply |
| CO5 | Discuss the design issues EV. | Apply |

**Course Contents:**

**UNIT I ELECTRIC VEHICLES AND VEHICLE MECHANICS** 9

Electric Vehicles (EV), Hybrid Electric Vehicles (HEV), Engine ratings, Comparisons of EV with internal combustion Engine vehicles, Fundamentals of vehicle mechanics.

**UNIT II ARCHITECTURE OF EV's AND POWER TRAIN COMPONENTS** 9

Architecture of EV's and HEV's – Plug-n Hybrid Electric Vehicles (PHEV)- Power train components and sizing, Gears, Clutches, Transmission and Brakes.

**UNIT III CONTROL OF DC AND AC DRIVES** 9

DC/DC chopper based four quadrant operations of DC drives – Inverter based V/f Operation (motoring and braking) of induction motor drive system – Induction motor and permanent motor based vector control operation – Switched reluctance motor (SRM) drives.

**UNIT IV BATTERY ENERGY STORAGE SYSTEM** 9

Battery Basics, Different types, Battery Parameters, Battery modeling, Traction Batteries.

**UNIT V ALTERNATIVE ENERGY STORAGE SYSTEMS** 9

Fuel cell – Characteristics- Types – hydrogen Storage Systems and Fuel cell EV – Ultra capacitors.

**TOTAL : 45 PERIODS**

Passed in Board of Studies Meeting (09.10.2021)

Approved in Academic Council Meeting (11.10.2021)

CHAIRMAN - BOARD OF STUDIES

**TEXT BOOKS:**


1 Iqbal Hussain, "Electric and Hybrid Vehicles: Design Fundamentals, Second Edition" CRC Press, Taylor & Francis Group, Second Edition (2018).

2 Ali Emadi, Mehrdad Ehsani, John M.Miller, "Vehicular Electric Power Systems", Special Indian Edition, Marcel dekker, Inc 2019.


**Mapping of Course Outcomes (COs) with Program Outcomes (POs) Program Specific Outcomes (PSOs)**

| COs | POs | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| CO1 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| CO2 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| CO3 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| CO4 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| CO5 | 3 | 2 | | | | | | | | | | 2 | 3 | 2 | 3 |
| | 3 | High | | | | 2 | Medium | | | | | 1 | Low | | |

| Formative assessment | | | |
|---|---|---|---|
| **Bloom's Level** | **Assessment Component** | **Marks** | **Total marks** |
| Remember | Classroom or Online Quiz | 5 | 15 |
| Understand | Class Presentation/Power point presentation | 5 | |
| | Attendance | 5 | |

| Summative assessment based on Continuous and End Semester Examination | | |
|---|---|---|
| **Bloom's Level** | **Internal Assessment [50 marks]** | **End Semester Examination [50 marks]** |
| Remember | 10 | 10 |
| Understand | 20 | 20 |
| Apply | 40 | 40 |
| Analyze | 30 | 30 |
| Evaluate | - | - |
| Create | - | - |

Passed in Board of Studies Meeting (09.10.2021)

Approved in Academic Council Meeting (11.10.2021)

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| 20PTE301 | RESEARCH METHODOLOGY AND IPR | 3/0/0/3 |
|---|---|---|
| Nature of Course | Professional Core | |
| Pre requisites | Fundamental knowledge in data collection and correlations | |

**Course Objectives**

The course is intended to

1. Understand the importance of Research
2. Developing a hypothesis, a research problem and related questions
3. Acquire knowledge in Data Collection and Analysis of Data
4. Effectively write reports
5. Impart scientific, statistical and analytical knowledge for carrying out research work effectively.

**Course Outcomes**

On successful completion of the course, students will be able to

| CO. No. | Course Outcome | Bloom's Level |
|---|---|---|
| CO1. | Formulate researchable questions | Understand |
| CO2. | Define a research strategy and design a research project | Understand |
| CO3. | Practice the principles of qualitative and quantitative social research | Understand |
| CO4. | Present complex data or situations clearly | Understand |
| CO5. | Learn about the different research techniques and research report. | Understand |

**Course Contents:**

**UNIT I Introduction to Research** 9

Nature, scope, and design of social research; Review of literature: qualitative (literary), quantitative (meta-analysis)

**UNIT II Hypothesis** 9

Hypothesis: sources, types and characteristics; Sample survey: sample and census survey, probability, non- probability and mixed sampling

**UNIT III Data Collection** 9

Methods of data collection: historical method, case study, observation, ethnographic methods, interview, questionnaire, focus group discussion, participatory rural appraisal, experimental method, pre-testing, and pilot survey; Scaling techniques different scales, item analysis, reliability, validity; Method of secondary data collection: sources, sample criteria, characteristics;

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Approved in Academic Council Meeting (09.03.2022)

CHAIRMAN - BOARD OF STUDIES

**UNIT IV Data Analysis** 9

Data analysis: descriptive statistics, mean difference test, analysis of variance and experimental design; Bivariate and multivariate correlation and regression; Factor analysis, Cluster analysis, Discriminant analysis, Structural equation modelling, non-parametric statistics, Content analysis

**UNIT V Report Writing** 9

Report writing: review, qualitative, and empirical article writing.

**Total : 45 Periods**

**Reference Books:**


1. C.M.Chaudhary, Research Methodology, RBSA Publishers, Jaipur, India 2009
2. R.Paneerselvam, Research Methodology, PHI Learning PvtLtd.,New Delhi 2009.
3. C.R.Kothari, Research Methodology, WishvaPrakashan, New Delhi,2001.
4. Donald H.McBurney, Research Methods, Thomson Asia Pvt. Ltd. Singapore,2002.
5. Donald R. Cooper and Ramela S. Schindler, Business Research Methods, Tata McGraw- Hill Publishing Company Limited, New Delhi,2000
6. G.W.Ticehurst and A.J.Veal, Business Research Methods, Longman,1999.
7. Ranjit Kumar, Research Methodology, Sage Publications, London, New Delhi,1999.
8. Raymond-Alain Thie'tart, et.al., Doing Management Research, Sage Publications, London, 1999.
9. Uma Sekaran, Research Methods for Business, John Wiley and Sons Inc., New York,2000


**Mapping of Course Outcomes (COs) with Programme Outcomes (POs) Programme Specific Outcomes (PSOs)**

| COs | POs | | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| CO1 | 3 | 3 | 2 | | | | | | | | | | | | |
| CO2 | 3 | 3 | 2 | | | | | | | | | | | | |
| CO3 | 3 | 3 | 2 | | | | | | | | | | | | |
| CO4 | 3 | 3 | 2 | | | | | | | | | | | | |
| CO5 | 3 | 3 | 2 | | | | | | | | | | | | |
| | 3 | High | | | | 2 | Medium | | | | | 1 | Low | | |

| Assessment | Marks | Weightage | Marks | CIA Marks | FE | Total Marks |
|---|---|---|---|---|---|---|
| CIA – I | 50 | 7.5 | 25 | 40 | 60 | 100 |
| CIA – II | 50 | 7.5 | | | | |
| CIA – III | 50 | 10 | | | | |
| Quiz/Presentation/Tutorial | 10 | 5 | 15 | | | |
| video presentation/Assignment | 10 | 5 | | | | |
| Attendance | 10 | 5 | | | | |

Passed in Board of Studies Meeting (24.02.2022)

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| 20PPEE302 | Power Electronics For Renewable Energy systems | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| Nature of Course | Professional Core | | | | |
| Pre requisites | Basic of Power Electronics, Renewable Energy System | | | | |

**Course Objectives**

The course is intended to

1. Provide the knowledge about the stand alone and grid connected renewable energy systems.
2. Indicate steps to design of power converters for renewable energy applications.
3. Comprehend the various operating modes of wind electrical generators and solar energy systems.
4. Analysis different power converters namely AC to DC, DC to DC and AC to AC converters for renewable energy systems.
5. Develop the maximum power point tracking algorithms.

**Course Outcomes**

On successful completion of the course the students will be able to

| CO. No | Course Outcome | Bloom's Level |
|---|---|---|
| CO 1 | Enumerate the impacts of renewable energy generation on environment | Remember |
| CO 2 | The late predict importance and qualitative analysis of solar energy sources | Understand |
| CO 3 | The importance and qualitative analysis of wind energy sources | Understand |
| CO 4 | Prioritize the performance of electrical machines for wind energy conversion and their characteristics | Apply |
| CO 5 | Contract suitable power converters for solar PV and wind energy systems | Analyse |

**Course Contents**

**UNIT I INTRODUCTION** 9

Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (cost-GHG Emission) -Qualitative study of different renewable energy resources ocean, Biomass, Hydrogen energy systems : operating principles and characteristics of: Solar PV, Fuel cells, wind electrical systems-control strategy, operating area.

**UNIT II ELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION** 9

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

**UNIT III POWER ELECTRONICS FOR SOLAR** 9

Block diagram of solar photo voltaic system : line commutated converters (inversion-mode) - Boost and buck-boost converters-selection of inverter, battery sizing, array sizing- standalone PV systems - Grid tied and grid interactive inverters- grid connection issues.

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**UNIT IV POWER ELECTRONICS FOR WIND** 9

Three phase AC voltage controllers-AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, matrix converters- Standalone operation of fixed and variable speed wind energy conversion systems- Grid connection Issues -Grid integrated PMSG and SCIG Based WECS.

**UNIT V HYBRID RENEWABLE ENERGY SYSTEMS** 9

Need for Hybrid Systems -Range and type of Hybrid systems-Case studies of Wind-PV- Maximum Power Point Tracking (MPPT).

**Total : 45 Periods**

Text Books


1. R.Seyezhai and R.Ramaprabha, "Power Electronics for Renewable Energy Systems", Scitech Publications, 2019.
2. Fang Lin Luo Hong Ye, "Renewable Energy systems", Taylor & Francis Group,2018.
3. S.N.Bhadra, D. Kastha, & S. Banerjee "Wind Electrical Systems", Oxford University Press, 2013.


Reference Books


1. P.S.Bimbhra,"Power Electronics",Khanna Publishers, 6rd Edition,2013.
2. Rashid .M. H "power electronics Hand book", Academic press, 2001.
3. Rai. G.D, "Nonconventional energy sources", Khanna publishes, 1993.


**Mapping of Course Outcomes (COs) with Programme Outcomes (POs) Programme Specific Outcomes (PSOs)**

| COs | POs | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO 1 | 3 | 2 | | 1 | | | | 1 | | | | | | |
| CO 2 | 3 | 3 | | 2 | | | | 1 | | | | | | |
| CO 3 | 3 | 3 | | 2 | | | | 1 | | | | | | |
| CO 4 | 3 | 2 | | 2 | | | | 2 | | | | | | |
| CO 5 | 3 | 3 | | 1 | | | | 2 | | | | | | |
| | 3-High | | | | 2-Medium | | | | 1-Low | | | | | |

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Approved in Academic Council Meeting (09.03.2022)

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| Formative Assessment | | | |
|---|---|---|---|
| Blooms Taxonomy | Assessment Component | Marks | Total marks |
| Remember | Quiz | 5 | 15 |
| Understand | Tutorial class / Assignment | 5 | |
| Apply | | | |
| | Attendance | 5 | |

| Summative Assessment | | | | |
|---|---|---|---|---|
| Bloom's Category | Internal Assessment Examinations (IAE) | | | Final Examinations (FE) |
| | IAE – I (7.5) | IAE – II (7.5) | IAE – III (10) | 60 |
| Remember | 10 | 10 | 10 | 20 |
| Understand | 30 | 30 | 30 | 60 |
| Apply | 10 | 10 | 10 | 20 |
| Analyse | | | | |
| Evaluate | | | | |
| Create | | | | |

Passed in Board of Studies Meeting (24.02.2022)

Approved in Academic Council Meeting (09.03.2022)

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| 20PPEE41 | Wind Energy Conversion Systems | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| Nature of Course | Professional Elective | | | | |
| Pre requisites | Basic of Power System | | | | |

**Course Objectives**

The course is intended to

1. Observe the knowledge about the Wind energy.
2. Explain about the design and control principles of Windturbine.
3. Differentiate the concepts of fixed speed and variable speed.
4. Determine the concepts of wind energy conversion systems.
5. Evaluate to analyse the grid integration issues

**Course Outcomes**

On successful completion of the course the students will be able to

| CO. No | Course Outcome | Bloom's Level |
|---|---|---|
| CO 1 | Recall acquire knowledge on the basic concepts of Wind energy conversion system | Remember |
| CO 2 | Contrast the predict importance and qualitative analysis of solar energy sources | Understand |
| CO 3 | Compare the importance and qualitative analysis of wind energy sources | Analyse |
| CO 4 | Prioritize the performance of electrical machines for wind energy conversion and their characteristics | Apply |
| CO 5 | Contract suitable power converters for solar PV and wind energy systems | Analyse |

**Course Contents**

**UNIT I INTRODUCTION** 9

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

**UNIT II WIND TURBINES** 9

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

**UNIT III FIXED SPEED SYSTEMS** 9

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

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**UNIT IV VARIABLE SPEED SYSTEMS** 9

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

**UNIT V GRID CONNECTED SYSTEMS** 9

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

**Total : 45 Periods**

**Text Books**


1. S.N.Bhadra, D.Kastha,S.Banerjee,"Wind Electrical Sytems",Oxford University Press,2018.
2. Ion Boldea, "Variable speed generators", Taylor & Francis group,2016.
3. S.Heir "Grid Integration of WECS", Wiley2014.


**Reference Book**


1. N. Jenkins," Wind Energy Technology" John Wiley &Sons,2010.
2. L.L.Freris "Wind Energy conversion Systems", Prentice Hall,2005.
3. E.W.Golding "The generation of Electricity by wind power", Redwood burn Ltd.,Trowbridge,2003.


**Mapping of Course Outcomes (COs) with Programme Outcomes (POs) Programme Specific Outcomes (PSOs)**

| COs | POs | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO 1 | 3 | 2 | | 1 | | | | 1 | | | | | | |
| CO 2 | 3 | 3 | | 2 | | | | 1 | | | | | | |
| CO 3 | 3 | 3 | | 2 | | | | 1 | | | | | | |
| CO 4 | 3 | 2 | | 2 | | | | 2 | | | | | | |
| CO 5 | 3 | 3 | | 1 | | | | 2 | | | | | | |
| | 3-High | | | | 2-Medium | | | | 1-Low | | | | | |

Passed in Board of Studies Meeting (24.02.2022)

CHAIRMAN - BOARD OF STUDIES

Approved in Academic Council Meeting (09.03.2022)

| Formative Assessment | | | |
|---|---|---|---|
| Blooms Taxonomy | Assessment Component | Marks | Total marks |
| Remember | Quiz | 5 | 15 |
| Understand | Tutorial class / Assignment | 5 | |
| Apply | | | |
| | Attendance | 5 | |

| Summative Assessment | | | | |
|---|---|---|---|---|
| Bloom's Category | Internal Assessment Examinations (IAE) | | | Final Examinations (FE) |
| | IAE – I (7.5) | IAE – II (7.5) | IAE – III (10) | 60 |
| Remember | 10 | 10 | 10 | 20 |
| Understand | 30 | 30 | 30 | 60 |
| Apply | 10 | 10 | 10 | 20 |
| Analyse | | | | |
| Evaluate | | | | |
| Create | | | | |

Approved in Board of Studies Meeting (24.02.2022)

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| 20PPEE42 | Energy Management and Auditing | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| Nature of Course | Professional Elective | | | | |
| Pre requisites | Electrical Machines, Power System | | | | |

**Course Objectives**

**The course is intended to**

1. The concepts behind economic analysis and Load management.
2. The concepts behind Load management
3. Explain the energy management on various electrical equipment's.
4. Analyse the metering and factors influencing cost function.
5. Illustrate the concept of lighting systems andcogeneration.

**Course Outcomes**

On successful completion of the course the students will be able to

| CO. No | Course Outcome | Bloom's Level |
|---|---|---|
| CO 1 | Describe about the need for energy management and auditing process | Remember |
| CO 2 | Determine about basic concepts of economic analysis and load management. | Apply |
| CO 3 | Illustrate the energy management on various electrical equipment's. | Apply |
| CO 4 | Prioritize knowledge on the concepts of metering and factors influencingcost function | Analyse |
| CO 5 | Focus on the concept of lighting systems, light sources and various forms of cogeneration | Analyse |

**Course Contents**

**UNIT I INTRODUCTION** 9

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

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

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

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

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

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CHAIRMAN - BOARD OF STUDIES

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**UNIT IV METERING FOR ENERGY MANAGEMENT** 9

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

**UNIT V LIGHTING SYSTEMS & COGENERATION** 9

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

**Total : 45 Periods**

**Text Books**


1. Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, "Guide to Energy Management", 7th Edition, The Fairmont Press, Inc.,2016
2. Amit K. Tyagi, "Handbook on Energy Audits and Management", TERI,2013.
3. Reay D.A, "Industrial Energy Conservation", 4st edition, Pergamon Press,2009.


**Reference Books**


1. Eastop T.D & Croft D.R, "Energy Efficiency for Engineers and Technologists", Logman Scientific & Technical,2003.


**Mapping of Course Outcomes (COs) with Programme Outcomes (POs) Programme Specific Outcomes (PSOs)**

| COs | POs | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO 1 | 3 | 2 | | 1 | | | | 1 | | | | | | |
| CO 2 | 3 | 3 | | 2 | | | | 1 | | | | | | |
| CO 3 | 3 | 3 | | 2 | | | | 1 | | | | | | |
| CO 4 | 3 | 2 | | 2 | | | | 2 | | | | | | |
| CO 5 | 3 | 3 | | 1 | | | | 2 | | | | | | |
| | 3-High | | | | 2-Medium | | | | 1-Low | | | | | |

Passed in Board of Studies Meeting (24.02.2022)

Approved in Academic Council Meeting (09.03.2022)

CHAIRMAN - BOARD OF STUDIES

| Formative Assessment | | | |
|---|---|---|---|
| Blooms Taxonomy | Assessment Component | Marks | Total marks |
| Remember | Quiz | 5 | 15 |
| Understand | Tutorial class / Assignment | 5 | |
| Apply | | | |
| | Attendance | 5 | |

| Summative Assessment | | | | |
|---|---|---|---|---|
| Bloom's Category | Internal Assessment Examinations (IAE) | | | Final Examinations (FE) |
| | IAE – I (7.5) | IAE – II (7.5) | IAE – III (10) | 60 |
| Remember | 10 | 10 | 10 | 20 |
| Understand | 30 | 30 | 30 | 60 |
| Apply | 10 | 10 | 10 | 20 |
| Analyse | | | | |
| Evaluate | | | | |
| Create | | | | |

Passed in Board of Studies Meeting (24.02.2022)

CHAIRMAN - BOARD OF STUDIES

Approved in Academic Council Meeting (09.03.2022)

| 20PPEE43 | Smart Grid | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| Nature of Course | Professional Elective | | | | |
| Pre requisites | Power System | | | | |

**Course Objectives**

**The course is intended to**

1. Identify about smart grid technologies.
2. Different smart meters and advanced meteringinfrastructure.
3. Familiarize the power quality management issues in SmartGrid.
4. Analyse the metering and factors influencing cost function.
5. Illustrate the concept of lighting systems and cogeneration.

**Course Outcomes**

On successful completion of the course the students will be able to

| CO. No | Course Outcome | Bloom's Level |
|---|---|---|
| CO 1 | Explain the basics of smart grid and its issues. | Understand |
| CO 2 | Complete about different Smart Grid technologies. | Apply |
| CO 3 | Establish about different smart meters and advanced metering infrastructure. | Apply |
| CO 4 | Illustrate on power quality management in smart grids | Analyse |
| CO 5 | Teach about the on LAN, WAN and cloud computing for smart grid applications. | Analyse |

**Course Contents**

**UNIT I INTRODUCTIONTO SMART GRID** **9**

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

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

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

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

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

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Approved in Academic Council Meeting (09.03.2022)

CHAIRMAN - BOARD OF STUDIES

**UNIT IV METERING FOR ENERGY MANAGEMENT** 9

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

**UNIT V LIGHTING SYSTEMS & COGENERATION** 9

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

**Total : 45 Periods**

**Text Books**


1. Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, "Guide to Energy Management", 7th Edition, The Fairmont Press, Inc.,2016
2. Amit K. Tyagi, "Handbook on Energy Audits and Management", TERI,2013.


**Reference Books**


1. Reay D.A, "Industrial Energy Conservation", 4st edition, Pergamon Press,2009.
2. Eastop T.D & Croft D.R, "Energy Efficiency for Engineers and Technologists", Logman Scientific & Technical,2003.


**Mapping of Course Outcomes (COs) with Programme Outcomes (POs) Programme Specific Outcomes (PSOs)**

| COs | POs | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO 1 | 3 | 2 | | 1 | | | | 1 | | | | | | |
| CO 2 | 3 | 3 | | 2 | | | | 1 | | | | | | |
| CO 3 | 3 | 3 | | 2 | | | | 1 | | | | | | |
| CO 4 | 3 | 2 | | 2 | | | | 2 | | | | | | |
| CO 5 | 3 | 3 | | 1 | | | | 2 | | | | | | |
| | 3-High | | | | 2-Medium | | | | 1-Low | | | | | |

Passed in Board of Studies Meeting (24.02.2022)

Approved in Academic Council Meeting (09.03.2022)

CHAIRMAN - BOARD OF STUDIES

| Formative Assessment | | | |
|---|---|---|---|
| Blooms Taxonomy | Assessment Component | Marks | Total marks |
| Remember | Quiz | 5 | 15 |
| Understand | Tutorial class / Assignment | 5 | |
| Apply | | | |
| | Attendance | 5 | |

| Summative Assessment | | | | |
|---|---|---|---|---|
| Bloom's Category | Internal Assessment Examinations (IAE) | | | Final Examinations (FE) |
| | IAE – I (7.5) | IAE – II (7.5) | IAE – III (10) | 60 |
| Remember | 10 | 10 | 10 | 20 |
| Understand | 30 | 30 | 30 | 60 |
| Apply | 10 | 10 | 10 | 20 |
| Analyse | | | | |
| Evaluate | | | | |
| Create | | | | |

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| 20PPEE44 | Hybrid Electric Vehicles | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| Nature of Course | Professional Elective | | | | |
| Pre requisites | Electrical Machines, Power System | | | | |

**Course Objectives**

**The course is intended to**

1. This course is aimed to introduce the fundamental concepts.
2. The principles of various hybrid electric vehicle.
3. Familiarize the electrically coupled hybrid electric drives.
4. Illustrate the concept of mechanically coupled hybrid electric drives.
5. The technologies with an insight into Power electronic converters.

**Course Outcomes**

On successful completion of the course the students will be able to

| CO. No | Course Outcome | Bloom's Level |
|---|---|---|
| CO 1 | Concept of electric and hybrid electric vehicles | Understand |
| CO 2 | The characteristics of internal combustion vehicles and hybrid electric vehicles. | Apply |
| CO 3 | Demonstrate the concept of electrically coupled hybrid electric drive trains | Understand |
| CO 4 | illustrate the concept of mechanically coupled hybrid electric drive trains | Apply |
| CO 5 | outline the importance of regenerative breaking | Apply |

**Course Contents**

**UNIT I INTRODUCTION TO ELECTRIC AND HYBRID ELECTRIC VEHICLES** 9

Environmental impact and history of modern transportation – Electric vehicles: configuration of EVs- performance of EVs – Tractive effort in normal driving- energy consumption – Hybrid electric vehicles: concept of hybrid electric drive trains – Architecture of hybrid electric drive trains.

**UNIT II IC PROPULSION AND ELECTRIC PROPULSION SYSTEMS** 9

Vehicle power plant and transmission characteristics – IC engine operating principle- operation parameters – DC Motor Drives – Induction Motor Drives – Permanent Magnetic BLDC Motor Drives – SRM Drives.

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**UNIT III ELECTRICALLY COUPLED HYBRID ELECTRIC DRIVE TRAIN** 9

Design principle of series (electrical coupling) hybrid electric drive train: Operation patterns – Control strategies – Design principles of a series (electrical coupling) hybrid drive train – Design example: Design of traction motor size – Design of the gear ratio – Verification of acceleration performance – Design of the power capacity of PPS – Fuel Consumption.

**UNIT IV MECHANICALLY COUPLED HYBRID ELECTRIC DRIVE TRAIN** 9

Parallel (mechanically coupled) hybrid electric drive train design: Drive train configuration and design objectives – Control strategies – parametric design of a drive train – Design and control methodology of series – parallel (torque and speed coupling) hybrid drive train: Drive train configuration – drive train control methodology – design and control principles of plug-in hybrid electric vehicles.

**UNIT V FUNDAMENTALS OF REGENERATIVE BREAKING** 9

Braking energy consumed in urban driving – braking energy versus vehicle speed – braking energy versus braking power – braking power versus vehicle speed – braking energy versus vehicle deceleration rate – braking energy on front and rear axles – brake system of EV, HEV, and FCV.

**Total : 45 Periods**

**Text Books**


1. Iqbal Hussain, "Electric and Hybrid Vehicles: Design Fundamentals", 2nd Edition, CRC Press, USA, 2011.
2. Chris Mi, Abul Masrur M & David Wenzhong Gao, "Hybrid Electric Vehicles Principles And Applications With Practical Perspectives", 1st Edition, Wiley Publication, UK, 2011.


**Reference Books**


1. Mehrded Ehsani, Yimin Gao & Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory and Design", 2nd Edition, CRC Press, USA, 2010.


**Mapping of Course Outcomes (COs) with Programme Outcomes (POs) Programme Specific Outcomes (PSOs)**

| COs | POs | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO 1 | 3 | 2 | | 1 | | | | 1 | | | | | | |
| CO 2 | 3 | 3 | | 2 | | | | 1 | | | | | | |
| CO 3 | 3 | 3 | | 2 | | | | 1 | | | | | | |
| CO 4 | 3 | 2 | | 2 | | | | 2 | | | | | | |
| CO 5 | 3 | 3 | | 1 | | | | 2 | | | | | | |
| | 3-High | | | | 2-Medium | | | | 1-Low | | | | | |

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