**Rashtreeya Sikshana Samithi Trust**

**R.V. College of Engineering**

*(Autonomous Institution Affiliated to Visvesvaraya Technological University, Belagavi)*

**

**Department of Electrical and Electronics Engineering**

**Master of Technology (M.Tech.)**

**Power Electronics**

**Scheme and Syllabus of**

**Autonomous System w.e.f 2016**

**R.V. College of Engineering, Bengaluru – 59**

*(Autonomous Institution Affiliated to Visvesvaraya Technological University, Belagavi )*

**Department of Electrical and Electronics Engineering**

**Vision:**

Promotion of technical excellence in Electrical and Electronics Engineering by offering programs to produce Engineers with dynamic well rounded personalities adaptable to ever increasing demands of emerging technologies involving analytical and practical skills, with commitment to research and development.

**Mission:**

* To provide technical education that combines rigorous academic study and the excitement of innovation enabling the graduates to engage in lifelong learning which is essential to improve performance continuously and excel in their career.
* To establish research and development center of repute so as to encourage active participation with industry by faculty and students to take on practical problems of industry and to provide feasible solutions.
* To establish tie-ups with institutions of national and international repute and to foster building up of a wide knowledge base to keep in tune with ever increasing demands of technologies

**POWER ELECTRONICS – Program**

**Program Specific Criteria (PSC)**

**Lead Society: IEEE**

1. **Curriculum**

The curriculum must prepare graduates to understand and analyze technical specifications and standards of Power Electronic devices and circuits; design and implement Power Electronic Systems in areas such as Power & Energy Systems, Electric Drives, Space technology, etc. The curriculum must also enable graduates to carry out innovative projects using state-of-the-art technology and integrate Power Electronics with other related domains, to facilitate collaborative multi-disciplinary research with integrity and ethics for benefit of the society

1. **Faculty**

The major professional competence of the faculty must be in electrical engineering, and the faculty should be experienced in the areas of power electronics engineering and applied domains such as power system, control system and instrumentation.

**Program Educational Objectives (PEO)**

M. Tech. in ­­­­Power Electronics Program, graduates will be able to:

1. Design, implement, protect, test and validate systems for Power Electronic Applications in Electric Drives and Power & Energy Systems.
2. Apply basic and advanced engineering knowledge to solve complex problems for integrated industrial power electronic systems.
3. Pursue research, communicate effectively, imbibe professional ethics and a desire for life-long learning.

**Program Outcomes (PO)**

M. Tech. in ­­­­Power Electronics Graduates will be able to:

1. **Scholarship of Knowledge:** Acquire in-depth knowledge of power electronic circuits for real time applications and an ability to evaluate, analyze and synthesize using existing modern tools for enhancement of knowledge.
2. **Critical Thinking:** Analyze complex engineering problems critically; apply independent judgment for synthesizing information to make intellectual and /or creative advances for conducting research in the domain of power electronic systems in a wider theoretical, practical and policy context.
3. **Problem Solving:** Think independently, conceptualize and evaluate a wide range of solutions and methods to solve problems in Power Electronics, with due consideration to society.
4. **Research Skill:** Conduct literature review, apply appropriate techniques and carry out research in the domain of Power Electronics and its industrial applications.
5. **Usage of modern tools:** Learn, choose, apply and develop appropriate techniques using modern simulation and IT tools related to power electronics.
6. **Collaborative and Multidisciplinary work:** Integrate Power Electronics with other related domains, to facilitate collaborative multi-disciplinary research.
7. **Project Management and Finance:** Understand and demonstrate management skills, assess and evaluate the economic feasibility; work effectively as a leader and a team member.
8. **Communication:** Communicate effectively with all stakeholders, create documents and reports as per the standards.
9. **Life-long Learning:** Infuse the desire and ability to engage in lifelong learning in the emerging area of power electronics.
10. **Ethical Practices and Social Responsibility:** Acquire professional integrity and ethics, understand the responsibility for sustainable development of the society.
11. **Independent and Reflective Learning:** Identify the shortcomings, examine the outcomes of one’s actions and implement corrective measures.

**Program Specific Outcomes (PSO)**

M. Tech. in Power Electronics Graduates will be able to:

1. Specify, select, test and characterize modern power electronic devices for an application.
2. Design, implement, protect, test and validate Power Electronic system for applications in the areas of Power Systems, Electric Drives and Space technology.

**R. V. College of Engineering, Bengaluru – 59**

*(An Autonomous Institution Affiliated to Visvesvaraya Technological University, Belagavi)*

**Department of Electrical and Electronics Engineering**

**M. Tech. in Power Electronics**

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| **THIRD SEMESTER** |
| **Sl. No** | **Course Code** | **Course Title** | **BoS** | **CREDIT ALLOCATION** | **Total Credits** |
| **Lecture****L** | **Tutorial****T** | **Practical****P** | **Self Study****S** |
| 1 | 16MPE31 | Switched Mode Power Converters | EE | 4 | 0 | 1 | 0 | 5 |
| 2 | 16MPE32x | Elective -5  | EE | 4 | 0 | 0 | 0 | 4 |
| 3 | 16MPE33x | Elective -6 | EE | 4 | 0 | 0 | 0 | 4 |
| 4 | 16MPE34x | Elective-7  | EE | 4 | 0 | 0 | 0 | 4 |
| 5 | 16MPE35 | Internship / Industrial Training\* | EE | 0 | 0 | 3 | 0 | 3 |
| 6 | 16MPE36 | Technical Seminar  | EE | 0 | 0 | 2 | 0 | 2 |
|  |  | **Total** |  | **16** | **0** | **6** | **0** | **22** |

\*To be completed during summer vacations and report to be submitted in the beginning of the third semester

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| **Elective 5** |
| 16MPE321 | High Voltage DC Transmission | 16MPE322 | Modern Industrial Instrumentation |
| **Elective 6** |
| 16MPE331 | Modern Rectifiers and Resonant Converters | 16MPE332 | Computational Electromagnetic Compatibility |
| **Elective 7** |
| 16MPE341 | Electric Hybrid Vehicles | 16MPE342 | **Wind and Solar Technologies** |

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**Department of Electrical and Electronics Engineering**

**M. Tech. in Power Electronics**

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| **FOURTH SEMESTER** |
| **Sl. No** | **Course** **Code** | **Course Title** | **BoS** | **CREDIT ALLOCATION** | **Total Credits** |
| **Lecture****L** | **Tutorial****T** | **Practical****P** | **Self Study****S** |
| 1 | 16MPE41 | Major Project | EE | 0 | 0 | 26 | 0 | 26 |
| 2 | 16MPE42 | Seminar | EE | 0 | 0 | 2 | 0 | 2 |
|  |  | **Total** |  | **0** | **0** | **28** | **0** | **28** |

**THIRD SEMESTER**

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| **Switched Mode Power Converters** |
| **Course Code** | **:** | **16MPE31** |  | **CIE Marks** | **:** | 100+50 |
| **Hrs/Week** | **:** | **L:T:P:S**  | **4:0:2:0** | **SEE Marks**  | **:** | 100+50  |
| **Credits**  | **:** | **5** |  | **SEE Duration** | **:** | **3+3 Hrs** |
| **Course Learning Objectives (CLO):**Graduates shall be able to1. Analyse the working of isolated, non-isolated and resonant converters
2. Design the converters
3. Design magnetic components
4. Model converters.
5. Analyze error amplifiers in control of converters.
 |
| **Unit I**  | **12 Hrs** |
| **Introduction-**Introduction to Switch mode power converters, Comparison between Linear and Switch mode Regulators, Classification **Non-Isolated DC-DC Converters-** Analysis and Design of non isolated converters Buck-Boost, C’uk and SEPIC topologies in continuous and Discontinuous current mode of operation. |
| **Unit – II** | **10 Hrs** |
| **Isolated DC- DC converters:** Analysis and Design of isolated DC- DC converters Flyback, Forward, Push Pull, Half Bridge and Full bridge topologies in continuous and discontinuous current mode operation.  |
| **Unit – III**  | **10 Hrs** |
| **Resonant Converters:** Introduction to soft witching,comparison between zero voltage and zero current switching, classification, ZVS, ZCS converters, series resonant, parallel resonant and series-parallel resonant converter topologies-analysis and design. |
| **Unit – IV** | **9 Hrs** |
| **Control of DC-DC converters**: Voltage control, current control, Design of type 2 and type 3 error amplifiers. Stability analysis of converters. PWM IC’s  |
| **Unit – V**  | **10 Hrs** |
| Design of magnetic components-inductors and transformersModeling of converters- small signal modeling, State space average modeling of non isolated converters. Design  |
| **Lab Experiments** |
| 1. Design and simulate Buck-Boost Converter
2. Implementation of BUCK- Boost Converter.
3. Design and simulate Cuk Converter
4. Implementation of Cuk Converter
5. Design and simulate SEPIC Converter
6. Implementation of SEPIC Converter
7. Design and simulate Forward Converter
8. Implementation of Forward Converter.
9. Design and simulate Flyback Converter
10. Design, Simulate and implement ZVS/ZCS converter
 |
| **Expected Course Outcomes:**After going through this course the student will be able to:1. Analyze the working of different DC-DC converter for continuous and discontinuous operation .
2. Design procedure for designing inductors and transformers.
3. Analysis of design of controllers.
4. Design of magnetic components and analyse modeling of converters.
 |
| **Reference Books:** |
|  | Ned Mohan " Power Electronics converters,applications and design", Wiley India Publisher, 3rd edition, 2011, ISBN: 978-0-471-22693-2  |
|  | Daniel w Hart " Power Electronics”, McGrawHill Education Publisher,2nd Edition, 2014, ISBN-13: 978-0073380674 |
|  | Rashid M H, "Power Electronics: Circuits, Devices, and Applications”, Prentice Hall Publisher, 2nd Edition, 2007, ISBN 13: 9780136789963 |
|  | * Paperback, L. Umanand, S. R. Bhat , “Design of Magnetic Components for Switched Mode Power Converters”, New Age International Publishers, 1st Edition, 2007, ISBN: 9788122403398, 8122403395
 |

**Scheme of Continuous Internal Evaluation (CIE) for Theory**

CIE will consist of TWO Tests, TWO Quizzes and ONE assignment. The test will be for 30 marks each and the quiz for 10 marks each. The assignment will be for 20 marks. The total marks for CIE will be 100 marks.

**Scheme of Continuous Internal Evaluation (CIE) for Practical**

CIE for the practical courses will be based on the performance of the student in the laboratory, every week. The laboratory records will be evaluated for 40 marks. One test will be conducted for 10 marks. The total marks for CIE (Practical) will be for 50 marks.

**Scheme of Semester End Examination (SEE) for Theory**

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one question from each unit. The total marks for SEE (Theory) will be 100 marks.

**Scheme of Semester End Examination (SEE) for Practical**

SEE for the practical courses will be based on conducting the experiments and proper results for 40 marks and 10 marks for viva-voce. The total marks for SEE (Practical) will be 50 marks.

**Mapping of Course Outcomes (CO) to Program Outcomes (PO)**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PO11** |
| **CO1** | **H** | **M** | **M** | **H** |  |  | **M** |  | **L** | **L** | **L** |
| **CO2** | **H** | **M** | **M** | **H** | **H** | **L** | **M** |  | **M** | **L** | **L** |
| **CO3** | **H** | **L** | **L** | **L** | **H** | **M** |  |  | **L** |  | **L** |
| **CO4** | **H** | **M** | **M** | **M** | **L** | **L** | **L** |  |  | **L** | **M** |

**Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)**

|  |  |  |
| --- | --- | --- |
|  | **PSO1** | **PSO2** |
| **CO1** | **M** | **H** |
| **CO2** | **H** | **M** |
| **CO3** | **M** | **M** |
| **CO4** | **H** | **H** |

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| **High Voltage DC Transmission** |
| **Course Code** | **:** | **16MPE321** |  | **CIE Marks** | **:** | 100 |
| **Hrs/Week** | **:** | **L:T:P:S**  | **4:0:0:0** | **SEE Marks**  | **:** | 100 |
| **Credits**  | **:** | **4** |  | **SEE Duration** | **:** | **3 Hrs** |
| **Course Learning Objectives (CLO):**Graduates shall be able to1. Understand the modern trends in long distance DC transmission and related issues
2. Analyse the control strategies and the importance of reactors in DC transmission system
3. Analyse the reactive power control requirement for stable operation of the system
4. Design the DC reactor and converter control circuits for HVDC system
 |
| Unit I | **10 Hrs** |
| **HVDC Power Transmission Technology:** Historical sketch, existing HVDC projects, Classification of HVDC links, Components of HVDC transmission system, Comparison of AC and DC Transmission, Application of DC Transmission, Modern trends in DC Transmission, Ground Return- advantages and disadvantages. Choice of converter configuration. |
| Unit II | 10Hrs |
| **HVDC CONVERTER:**Introduction to line commutated converter, analysis of six and twelve pulse converter without overlap. Effect of smooting reactor, effect of smoothning reactor. Two and three level voltage source converter, pulse width modulation. Analysis of converter two and three , three and four valve conduction. Conduction modes. 12 pulse detailed analysis |
| Unit III | **10 Hrs** |
| **CONTROL OF CONVERTERS AND HVDC LINK:** Converter control characteristics, firing angle control,CEA control, Starting and stopping of DC link, Power control , frequency control. Reactive power control, tap changer control. Control of voltage source converter. **Converter Faults and protection:**Converter faults, protection against over voltages, over currents in converter station. Surge arrester. Protection agains faults in voltage source converter.. |
| Unit IV | **10 Hrs** |
| **SMOOTHING REACTOR AND DC LINE:**Smooting reactors, effects of corona loss, DC line insulators, Transient over voltages in DC line, protection in DC line. Detection and protection of faults, DC breakers.**Reactive power control:**Reactive power control in steady state and transient state. Sources of Reactive power, SVC and STATCOM. |

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| Unit V | **10 Hrs** |
| **Power flow analysis in AC/DC system:**Introduction to DC system model, procedure, inclusion of constraints, Power flow analysis under dynamic conditions, power flow with VSC based HVDC system.Introduction to stability concepts, analysis of voltage stability in asynchronous AC/DC system. **Multi terminal DC system**: Introduction, types , control and protection. |
|  |
| **Course Outcomes:**At the end of the course the student will be able to 1. Understand the importance of modern long distance transmission technology, and related issues.
2. Analyze the control of converter and faults in the system
3. Evaluate the power control in AC/DC systems and its modeling.
4. Design DC reactor, filters and transmission line as per the specifications.
 |
| **Refernce Books:** |
|  | Kimbark E.W. ,“Direct current Transmission”, Vol 1, Wiley Inter science Publication,1971. ISBN 0471475807, 9780471475804 |
|  | Padiyar K R , “High Voltage Direct Current Power Transmission system- Technology and Systems Interactions” .,Wiley Eastern Ltd. Publication, 1992. ISBN-13: 978-1906574772 |
|  | Arrillage , ‘ High voltage direct current transmission”, Peter pregrinus , London Publication, 1983. ISBN 0906048974, 9780906048979 |
|  | Adamson C Hingorani N G “ High voltage direct current power transmission”, Grraway ltd, London Publication, 1960. |
|  | S Kamakshaiah and V Kamaraju, “ HVDC Transmssion”, Tata McGraw-Hill Education Pvt. Ltd., 2011, ISBN 10: 0071072535 / ISBN 13: 9780071072533 |

**Scheme of Continuous Internal Evaluation (CIE)**

CIE will consist of TWO Tests, TWO Quizzes and ONE assignment. The test will be for 30 marks each and the quiz for 10 marks each. The assignment will be for 20 marks. The total marks for CIE will be 100 marks.

**Scheme of Semester End Examination (SEE)**

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one question from each unit. The total marks for SEE (Theory) will be 100 marks.

**Mapping of Course Outcomes (CO) to Program Outcomes (PO)**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PO11** |
| **CO1** | **H** | **H** | **M** | **L** | **M** | **M** | **--** | **---** | **M** | **--** | **L** |
| **CO2** | **H** | **H** | **M** | **L** | **M** | **M** | **L** | **---** | **M** | **M** | **L** |
| **CO3** | **H** | **M** | **M** | **M** | **M** | **M** | **L** | **M** | **M** | **--** | **L** |
| **CO4** | **H** | **H** | **L** | **M** | **M** | **M** | **L** | **M** | **M** | **M** | **M** |

**Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)**

|  |  |  |
| --- | --- | --- |
|  | **PSO1** | **PSO2** |
| **CO1** | **M** | **H** |
| **CO2** | **H** | **M** |
| **CO3** | **M** | **M** |
| **CO4** | **H** | **H** |

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| **Modern Industrial Instrumentation (Elective 5)** |
| **Course Code** | **:** | **16MPE322** |  | **CIE Marks** | **:** | 100 |
| **Hrs/Week** | **:** | **L:T:P:S**  | **4:0:0:0** | **SEE Marks**  | **:** | 100 |
| **Credits**  | **:** | **4** |  | **SEE Duration** | **:** | **3 Hrs** |
| **Course Learning Objectives (CLO):**Graduates shall be able to1. Explain the function of different types of sensors
2. Choose a sensor, transducers for a particular application
3. Understand the application of laser for measurements
4. Apply concepts of physics and electronics to laser and optical instrumentation
5. Have a knowledge of communication interfaces with measuring instruments
 |
| **Unit – I**  | **10Hrs** |
| **Sensor Technologies**Sensors, Signals, and Systems , Sensor Classification , Potentiometric Sensors ,CapacitiveSensors, Inductive and Magnetic Sensors, LVDT and RVDT, Eddy Current Sensors, Hall EffectSensors, Optical Sensors, Proximity Detector with Polarized Light, Fiber-Optic Sensors,thickness and level sensors, Ultrasonic Sensors, Thin Film Sensors, Liquid Level Sensors. |
| **Unit – II** | **10 Hrs** |
| **Transducers :** Classification, selection of transducers, Resistance, inductance and capacitance type of transducers, measurement of displacement, strain, force, torque, liquid level, pressure, velocity and acceleration |
| **Unit – III**  | **10 Hrs** |
| **Laser Instrumentation:**Laser principles, characteristics, classification and construction; Measurement of distance - Interferometric methods, beam modulation telemetry, pulse echo techniques. Laser Doppler velocimetry- Holography-principle, applications of holography, holographic computer memories, laser welding, laser machining, laser printing and laser spectroscopy |
| **Unit – IV** | **10 Hrs** |
| **Optical Fiber Instrumentation** - principles of light propagation through a fiber – Different types of fibers and their properties –Transmission characteristics of optical fiber –Absorption losses – Scattering losses – Dispersion- advantages and disadvantages of optical fibers. Fiber optic Instrumentation system - Interferometric method of measurement of length - Moire fringes – Measurement of pressure, temperature, current, voltage, liquid level and strain. Fiber optic gyroscope – polarization maintaining fibers – applications |
| **Unit – V**  | **10 Hrs** |
| **Digital Instrumentation :** Digital counter-timer, frequency meter, digital voltmeter and multimeter, digital storage oscilloscope, Digital Encoder-Disc type, Digital Tachometer, Frequency Output type transducers, The signal and conversion, The Instrument System, Virtual Instrumentation,. Modulation of Digital Data, Transmission Channels, Wireless I/O, Data Loggers – Introduction to IEEE 488/GPIB Buses, Communication with Instruments by RS232 cable . |

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| **Course Outcomes** At the end of the course the student will be able to 1. Distinguish between different sensor and transducers
2. Apply the concepts of physics and electronics to laser and optical instrumentation
3. Justify the need for digital instrumentation and its application to measure different parameters
4. Design and propose a measuring system with associated sensors and transducers for a particular application.
 |
| **References**  |
| 1. 1.
 |  **Ernest Doebelin & Dhanesh Manik**,“Measurement System” , Tata McGraw Hill, 6th Edition, 2011, ISBN : 9780070699687 |
| 1. 2.
 | Jon S. Wilson , “Sensor Technologies”, Newnes Publisher, 2nd Edition, 2004, ISBN : 0-7506-7729-5 |
| 1. 3.
 | C.K.Sarkar and D.C. Sarkar, “Optoelectronics and Fiber Optics Communication”, New Age Int. Pub., 2nd edition, 2012, ISBN : 978-81-224-3457-6 |
| 1. 4.
 | Wilson and Hawkes, "Laser principles and applications", Prentice Hall of India Publisher, 2003, ISBN 9780135236970 |
| 1. 5
 | Kalsi, “Electronic Instrumentation “,Tata McGraw Hill Eduction c, 2004, ISBN : 978007070206-6, 9780070583702 |

**Scheme of Continuous Internal Evaluation (CIE)**

CIE will consist of TWO Tests, TWO Quizzes and ONE assignment. The test will be for 30 marks each and the quiz for 10 marks each. The assignment will be for 20 marks. The total marks for CIE will be 100 marks.

**Scheme of Semester End Examination (SEE)**

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one question from each unit. The total marks for SEE (Theory) will be 100 marks.

**Mapping of Course Outcomes (CO) to Program Outcomes (PO)**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PO11** |
| **CO1** | **M** | **L** | **L** | **M** | **L** | **-** | **-** | **L** | **L** | **L** | **L** |
| **CO2** | **M** | **M** | **M** | **L** | **M** | **-** | **-** | **L** | **M** | **L** | **M** |
| **CO3** | **H** | **H** | **M** | **M** | **M** | **L** | **L** | **M** | **M** | **M** | **M** |
| **CO4** | **H** | **H** | **H** | **H** | **H** | **L** | **L** | **M** | **M** | **M** | **H** |

**Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)**

|  |  |  |
| --- | --- | --- |
|  | **PSO1** | **PSO2** |
| **CO1** | **M** | **M** |
| **CO2** | **M** | **M** |
| **CO3** | **M** | **M** |
| **CO4** | **H** | **H** |

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| **MODERN RECTIFIERS AND RESONANT CONVERTERS** |
| **Course Code** | **:** | **16MPE331** |  | **CIE Marks** | **:** | 100 |
| **Hrs/Week** | **:** | **L:T:P:S**  | **4:0:0:0** | **SEE Marks**  | **:** | 100 |
| **Credits**  | **:** | **4** |  | **SEE Duration** | **:** | **3 Hrs** |
| **Course Learning Objectives (CLO):**Graduates shall be able to1 compare ideal and practical rectifier circuits in terms of losses and efficiency.2Analyzeseries and parallel resonant converters3Analyze various resonant DC-DC converter topologies4Design series and parallel resonant inverters5 Evaluate the load network parameters for ZVS and ZCS inverters |
| **Unit – I**  | **9 Hrs** |
| **Pulse Width Modulated Rectifiers** Properties of Ideal rectifiers-Realization of non-ideal rectifier-Control of current waveform-Average current control-Current programmed Control- Hysteresis control- Nonlinear carrier control-Single phase converter system incorporating ideal rectifiers- Modelling losses and efficiency in CCM high quality rectifiers-Boost rectifier Example-expression for controller duty cycle-expression for DC load current-solution for converter Efficiency η. |
| **Unit – II** | **12 Hrs** |
| **Series and Parallel Resonant Converters** Half-Bridge Series-Resonant Converter, Full-Bridge Series-Resonant Converter, Design of Half-Bridge SRC, Half-Bridge and Full-Bridge Parallel Resonant Converters, Half-Bridge Series-Parallel-Resonant Converter, Design of Half-Bridge SPRC, Full-Bridge Series-Parallel-Resonant Converter  |
| **Unit – III**  | **12Hrs** |
| **Quasi-resonant and Multi-resonant DC-DC Power Converters** Zero-Voltage-Switching Quasi-resonant DC-DC Converters, Buck ZVS Quasi-resonant DC-DC Converter, Boost ZVS Quasi-resonant DC-DC Converter, Buck-Boost ZVS Quasi-resonant DC-DC Converter, Zero-Current-Switching Quasi-resonant DC-DC Converters, Buck ZCS Quasi-resonant DC-DC Converter, Boost ZCS Quasi-resonant DC-DC Converter, Buck-Boost ZCS Quasi-resonant DC-DC Converter, Zero-Voltage Switching Multi-resonant DC-DC Converters, Zero-Current Switching Multi-resonant DC-DC Converters, Zero-Voltage Transition PWM Converters, Zero-Current Transition Converters |
| **Unit – IV** | **9Hrs** |

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| **Resonant Inverters****Series Resonant Inverter**: Principle of Operation, Topologies of Class D Voltage-Source Inverters, Analysis, Voltage Transfer Function, Efficiency, Design Example, Class D Full-Bridge Series-Resonant Inverter, Relationships Among Inverters and Rectifiers, **Parallel-Resonant Inverter,** Analysis, Short-Circuit and Open-Circuit Operation, Electronic Ballast for Fluorescent Lamps, Design Example, Full-Bridge Parallel-Resonant Inverter, **Series-Parallel-Resonant Inverter,** Analysis, Design Example, Full-Bridge Series-Parallel-Resonant Inverter |
| **Unit – V**  | **8Hrs** |
| **Zero-Voltage and Zero-Current Switching Resonant Inverter**Principle of Operation and Analysis of ZVS Inverters, Matching Resonant Circuits, Design Example, Push-Pull Class E ZVS Inverter, Principle of Operation and Analysis of ZCS Inverters, Power Relationships, Element Values of Load Network, Design Example |
| **Expected Course Outcomes:**After going through this course the student will be able to:1. Explain basic concepts of modern rectifiers and resonant converters.
2. Describe ZVS and ZCS for inverters and converters.
3. Analyse different resonant converter topologies
4. Design high quality rectifiers and resonant converters.
 |
| **Reference Books:** |
|  | Mohan, Undeland and Robbins,"Power Electronics: Converter, Applications and Design", Wiley India, 2011, ISBN-13: 9781848003170 |
|  | **Erickson,** Robert W**., Maksimovic and** Dragan, “Fundamentals of Power Electronics", Springer Publisher, 2001, ISBN 978-0-306-48048-5 |
|  | Marian K. Kazimierczuk, DariuszCzarkowski, “Resonant Power Converters”, 2nd Edition, Wiley-IEEE Press, March 2011, ISBN: 978-0-470-90538-8 |
|  | Technical literature – papers published in power electronics related journal |

**Scheme of Continuous Internal Evaluation (CIE)**

CIE will consist of TWO Tests, TWO Quizzes and ONE assignment. The test will be for 30 marks each and the quiz for 10 marks each. The assignment will be for 20 marks. The total marks for CIE will be 100 marks.

**Scheme of Semester End Examination (SEE)**

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one question from each unit. The total marks for SEE (Theory) will be 100 marks.

**Mapping of Course Outcomes (CO) to Program Outcomes (PO)**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PO11** |
| **CO1** | **H** | **L** | **L** | **M** | **L** | **L** | **-** | **L** | **L** | **L** | **L** |
| **CO2** | **M** | **M** | **M** | **M** | **M** | **L** | **-** | **L** | **M** | **L** | **M** |
| **CO3** | **H** | **H** | **M** | **M** | **H** | **L** | **L** | **M** | **M** | **M** | **M** |
| **CO4** | **M** | **H** | **H** | **H** | **H** | **L** | **L** | **M** | **M** | **M** | **H** |

**Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)**

|  |  |  |
| --- | --- | --- |
|  | **PSO1** | **PSO2** |
| **CO1** | **H** | **H** |
| **CO2** | **H** | **M** |
| **CO3** | **M** | **M** |
| **CO4** | **H** | **H** |

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| **Computational Electro Magnetic compatibility** |
| **Course Code** | **:** | **16MPE332** |  | **CIE Marks** | **:** | 100 |
| **Hrs/Week** | **:** | **L:T:P:S**  | **4:0:0:0** | **SEE Marks**  | **:** | 100 |
| **Credits**  | **:** | **4** |  | **SEE Duration** | **:** | **3 Hrs** |
| **Course Learning Objectives (CLO):**Graduates shall be able to1. To Apply the knowledge of interference and compatibility methods to solve the equipment noise problem
2. To Design and Analyze through circuits like cabeling, grounding, shielding etc
3. To reduce the risk of external noise harming the general conditions electromagnetic compatibility should be a major design objective.
4. To distinguish between different methods and also various concept theory present in complexity of EMI study and structuring.
5. To develop the ability to analyze the conditions of EMI related problems in power electronics devices.
 |
| **Unit – I**  | **10Hrs** |
| **INTRODUCTION**EMC regulation, Typical noise path and use of network theory,Methods of noise coupling,Method of eliminating interferences,-STD explanation **SHIELDING:** Near fields and Far fields**,** Shielding effectiveness, Absorption and Reflection losses ,different analysis with respect to Absorption losses and Reflection losses ,Apertures, Conductive gaskets and windows  |
| **Unit – II** | **10Hrs** |
| **GROUNDING:** safety grounds, signal grounds, single point ground and multi point ground systems, Hybrid grounds, Functional Ground layout, Practical Low-frequency grounding, Hardware grounds, Grounding of cable shields, Guard shields, Guard meters.**Contact protection ;** Glow Discharge ,Arc Discharges, contact materials, contact Rating Loads with high inrush current Contact protection fundamentals, Transient suppression for inductive loads Inductive loads controlled by Transistor switch, Resistive load contact protection, Contact protection networks for inductive loads  |
| **Unit – III**  | **10Hrs** |
| **Intrinsic Noise Sources :** Thermal noise,Characteristics of Thermal Noise, Equivalent noise band width, Shot noise ,Contact noise, Pop corn noise, Addition of noise voltages, Measuring Random noises**ACTIVE Device Noise;**Noise factor, Measurement of noise factor, Calculating S/N ratio and input Noise voltages from noise factor ,Noise voltage and current model, Measurement of Vn and In ,Calculation of Noise factor and S/N Ratio from Vn –In characteristic, optimum source resistance ,Noise temperature, Noise factor of cascaded stages |

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| **Unit – IV** | **10 Hrs** |
| **Digital circuit Noise and layout:** Frequency versus time domain, Analog v/s Digital circuits, Digital Logic Noise Internal noise sources,Digital circuit ground noise, Power distribution,Noise voltage objectives, Measuring noise voltages ,Unused inputs, static pcb effects , dynamic pcb effects**Basic linear design**: Parasitic Effects in Inductors ,Q or "Quality Factor" , Designing Controlled Impedances Traces on PCBs, Micro strip PCB Transmission Lines, Grounding and Decoupling Mixed-Signal ICs with Low Digital Currents, Sensitive analog components: |
| **Unit – V**  | **8Hrs** |
| **Digital circuit Radiation:**Problems caused by radiation , Differential-mode radiation, Controlling differential mode radiation, Common mode radiation, Controlling common mode radiation, Engineering documentation and EMC Radiation hardening,Radiation-hardening techniques,Military and space industry applications. |
| **Expected Course Outcomes:**After going through this course the student will be able to:1. Understand the concept of EMI and EMC
2. Analyze the causes of occurrence and minimizing of EMI
3. Evaluate, assess and compare the, operation of equipments, under EMI and EMC
4. Design different steps, to obtain EMI controlled conditions for equipments
 |
| **Reference Books:** |
|  |  Henry .W. Ott, “Noise reduction techniques in electronics systems”, John Wiley publication, 4th edition, 2014, ISBN: 978-0-470-18930-6  |
|  | William D Greason , “Electrostatic Damage in Electronics: Devices and Systems” John Wiley and sons, 4th edition , 1986, ISBN:10: 0471915394 |
|  | Tim Williams, “EMC for Product Designers”, Elsevier Publication, Fourth Edition, 2006, ISBN – 13: 978-0-75-0681704 |
|  | Clayton R Paul Wiley-Blackwell, “Introduction to Electro Magnetic compatibility”, Wiley-Blackwel Publication, Revised 4th  Edition, 2010, ISBN: 978-0470189306  |

**Scheme of Continuous Internal Evaluation (CIE)**

CIE will consist of TWO Tests, TWO Quizzes and ONE assignment. The test will be for 30 marks each and the quiz for 10 marks each. The assignment will be for 20 marks. The total marks for CIE will be 100 marks.

**Scheme of Semester End Examination (SEE)**

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one question from each unit. The total marks for SEE (Theory) will be 100 marks.

**Mapping of Course Outcomes (CO) to Program Outcomes (PO)**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PO11** |
| **CO1** | **H** | **L** | **L** | **M** | **L** | **L** | **-** | **L** | **L** | **L** | **L** |
| **CO2** | **H** | **M** | **M** | **M** | **M** | **L** | **-** | **L** | **M** | **L** | **M** |
| **CO3** | **H** | **H** | **H** | **M** | **H** | **M** | **L** | **M** | **M** | **M** | **M** |
| **CO4** | **H** | **H** | **H** | **H** | **H** | **M** | **L** | **M** | **M** | **M** | **H** |

**Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)**

|  |  |  |
| --- | --- | --- |
|  | **PSO1** | **PSO2** |
| **CO1** | **M** | **H** |
| **CO2** | **H** | **M** |
| **CO3** | **M** | **M** |
| **CO4** | **H** | **H** |

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| **Electric Hybrid Vehicles**  |
| **Course Code** | **:** | **16MPE341** |  | **CIE Marks** | **:** | 100 |
| **Hrs/Week** | **:** | **L:T:P:S**  | **4:0:0:0** | **SEE Marks**  | **:** | 100 |
| **Credits**  | **:** | **4** |  | **SEE Duration** | **:** | **2 Hrs** |
| **Course Learning Objectives (CLO):**Graduates shall be able to1. Understand the fundamental concept and architecture of Hybrid Electric Vehicles -EHVs
2. Understand and analyze Plug-in hybrid vehicle and Fuel cell vehicles
3. Understand and analyze the electric machines and drives used in hybrid Electric vehicles
4. Understand the Design and Modeling of components of HEV system
5. Analyze the case studies and implement the concept for adding novelty in design and manufacturing of EHVs
 |
| **Unit – I**  | **10Hrs** |
| **Review and Introduction to Hybridization of Automobile:** History of hybrid vehicles, architectures of HEVs, series and parallel HEVs, complex HEVs. Fundamentals of vehicle,components of conventional vehicle and propulsion load; Drive cycles and drive terrain; Concept of electric vehicle and hybrid electric vehicle; Plug-in hybrid vehicle, constituents of PHEV, comparison of HEV and PHEV; Fuel Cell Vehicles and its constituents. |
| **Unit – II** | **10Hrs** |
| **Plug-in Hybrid Electric Vehicle:**PHEVs and EREVs, blended PHEVs, PHEV Architectures, equivalent electric range of blendedPHEVs; Fuel economy of PHEVs, power management of PHEVs, end-of-life battery for electric power grid support, vehicle to grid technology, PHEV battery charging. |
| **Unit – III** | **11 Hrs** |
| **Power Electronics in HEVs:**Rectifiers used in HEVs, voltage ripples; Buck converter used in HEVs, non-isolated bidirectionalDC-DC converter, regenerative braking, voltage source inverter, current source inverter, isolated bidirectional DC-DC converter, P WM rectifier in HEVs, EV and PHEV battery chargers. |
| **Unit – IV** | **10 Hrs** |
| **Electric Machines and Drives in HEVs (part 1**): Induction motor drives, Field oriented control of induction machines; Vector control of induction motor drives , Permanent magnet motor drives; switched reluctance machines; - flux weakening; optimization; thermal management;Case studies: vector control and field control of Induction motor drives |
| **Unit – V** | **09 Hrs** |
| **Electric Machines and Drives in HEVs (part 2**): Switched reluctance motors; Doubly salient permanent magnet machines, brushless DC motor drives ; finite element analysis, speed controller design, sensor less control ,vector control of permanent magnet machines. Case studies on control strategies: constant torque angle control, unity power factor control,  |
| **Expected Course Outcomes:**After going through this course the student will be able to:1. Understand the concepts and basic operation of Hybrid Electric Vehicle system
2. Analyze the plug in operation of Hybrid Electric Vehicle system
3. Understand the design techniques of Electric Drive system.
4. Analyze the issues in the application of control of Electric Drive system.
 |
| **Reference Books:** |
|  | Mi Chris, Masrur A., and Gao D.W., “ Hybrid Electric Vehicle: Principles and Applications with Practical Perspectives”, Wiley Publisher, 1st Edition, 2011,**ISBN**:0-824-77653-5 |
|  | Dubey G.K. “Power Semiconductor controlled drives”, Prentice Hall inc, A division of Simon andSchester England cliffs, New Jersey 1989. ISBN-13: 978-0136868903 |
|  | M. H. Rashid, "Power Electronics - Circuits, Devices and Applications", P.H.I Private Ltd. NewDelhi, Fourth Edition, 1994, ISBN-13: 978-0133125900 |
|  | R. Krishnan, “Electric motor drives: modeling, analysis and control, P.H.I Private Ltd. NewDelhi, Second Edition, 2001, ISBN 10: [0130910147](https://www.abebooks.com/products/isbn/9780130910141?cm_sp=bdp-_-9780130910141-_-isbn10) / ISBN 13: [9780130910141](https://www.abebooks.com/products/isbn/9780130910141?cm_sp=bdp-_-9780130910141-_-isbn13) |
|  | Bimal K Bose, “Modern Power Electronics and AC Drives” P.H.I Private Ltd. New Delhi, Second Edition, 2001, **ISBN-13:** 978-0130167439 |

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**Scheme of Semester End Examination (SEE)**

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one question from each unit. The total marks for SEE (Theory) will be 100 marks.

**Mapping of Course Outcomes (CO) to Program Outcomes (PO)**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| CO’s | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
| CO1 | M | M | H | M | M | L | L | L | H | M | M |
| CO2 | H | M | M | L | L | L | L | M | M | H | M |
| CO3 | H | H | M | H | H | L | L | L | M | L | M |
| CO4 | M | M | L | M | M | L | L | M | H | L | M |

**Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)**

|  |  |  |
| --- | --- | --- |
|  | **PSO1** | **PSO2** |
| **CO1** | **H** | **M** |
| **CO2** | **M** | **H** |
| **CO3** | **H** | **M** |
| **CO4** | **H** | **H** |

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| **Wind and Solar Technologies** |
| **Course Code** | **:** | **16MPE342** |  | **CIE Marks** | **:** | 100 |
| **Hrs/Week** | **:** | **L:T:P:S**  | **4** | **SEE Marks**  | **:** | 100 |
| **Credits**  | **:** | **4:0:0:0** | **4** | **SEE Duration** | **:** | **3 Hrs** |
| **Course Learning Objectives:** 1. To provide opportunity for students to Learn and work on multidisciplinary projects.
2. To familiarize the students with the basic concepts of nonconventional energy sources and allied technological systems for energy conversion
3. To impart skill to formulate, solve and analyze basic Non – conventional energy problems and prepare them for graduate studies.
4. To enable the student to design primarily solar and wind power systems.
5. To expose the students to various applications of solar, wind systems.
 |
| **Unit I** | **10 Hrs** |
| **An introduction to energy sources:** Industry overview, incentives for renewable, utility perspective,relevant problems discussion, current positions of renewable energy conditions **Over view of electrical design of wind power plant:** Electrical design of wind power plant, Wind plant performance requirement, Economic evaluation factor, collection system Electrical Design,**Over view of electrical design of solar power plant:** Electrical design of solar power plant, Economic analysis of thermal applications |
| **Unit – II** | **13 Hrs** |
| **Solar collectors and Energy storage****Solar collectors:** classification, comparison of concentrating and non- concentrating types, performance indices, Liquid flat plate collector, calculation of efficiency, Effect of various parameters on performance, Flat plate Air heating collector, Evacuated tube collector, Modified Flat-plate collector compound parabolic concentrator**Solar Energy storage**: Introduction, sensible heat storage, Analysis of liquid storage, tank Analysis of packed bed storage, Latent heat storage, Thermo chemical storage **solar pond**- principle of working, Extraction of thermal energy and applications of solar pond**Wind energy storage** : introduction, Storage technologies-pumped hydro storage, compressed air energy storage, Battery storage, Fly Wheel, Storage **for wind integration: Applications** of storage with High wind, integration of wind generation with storage, **Studies on operation of storage with High wind penetration:** curtailment, costs, operation of storage and effects on system |

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| **Unit – III**  | **13 Hrs** |
| **Power quality characteristics with wind turbines:** introduction power quality standards, **power quality characteristics**,-Rated data, Emission of voltages fluctuations and flicker, Current harmonics, inter harmonics and Higher frequency components, Response to voltage dips, Active power capabilities and control, Reactive power capabilities and control, Grid protection and Reconnection times **impact on voltage quality:** introduction ,case study specifications, slow voltage variation Flicker, voltage dips, Harmonic voltage**Measurement of electrical characteristics;** introduction, power quality measurement procedure specification, **Practical experience with power quality and power:** introduction, voltage variation, Flicker, Harmonics, Transients, Frequency**Technical regulations for the inter connections of wind power:** introduction, over view of technical regulations, comparison of technical interconnection regulations, new interconnection requirements at wind plant level, interconnection practice |
| **Unit – IV** | **10 Hrs** |
| **Transmission systems for offshore wind power plant and operation planning:** introduction,General Electrical aspects, Transmission system to shore, From cluster approach to offshore transmission grid, off shore grid system, New system solution,**New cable systems for offshore wind power plant**: introduction, Technical Background, Power transmission with Bipolar HVAC cable system, voltage definitions and Transformer groups, Submarine cable, HVAC Bipolar land cable system**Control concept: Introduction**, model, power limitation, calculation, Results |
| **Unit – V**  | **10 Hrs** |
| **PV Technology:** Photovoltaic power, Building integrated PV system, PV cell technologies, solar energy maps, Technology trends, **Photovoltaic Power Systems**: PV cell, Module and Array, Equivalent electrical circuit, open-circuit voltage and short-circuit current, i-v and p-v curves, Array design(different methodologies),peak-power operation, system components |
|  |
| **Expected Course Outcomes:**After going through this course the student will be able to:CO1: Demonstrate an understanding of the scientific principles of methodology of Non-conventional energyCO2: Acquire working knowledge of different Renewable energy science-related topics.CO3: Ability to analyze the system related concepts effectively in the wind energy designingCO4: Students will be able to decide the appropriate procedures to ensure that the working model has developed properly |
| **Reference Books:** |
|  | Thomas Ackermann “wind power in power systems wiley publishers ,2nd edition,2008,ISBN978-0-470-1570-1 |

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| --- | --- |
|  | Mukund R Patel “wind and solar power systems Design ,Analysis and operation ”Taylor and Francis publishers ,2nd edition,2006,ISBN978-0-8493-1570-1 |
|  | Fang linluohongye “ Renewable energy systems “CRCpress 2009, ISBN:978-1-470-4398 |
|  |  Solar energy hand book – edited by William. Dickenson ASISES, Network, ISBN -13: 978-0865716216. |
|  | Partain, L. D., “Solar Cells and Their Applications”. John Wiley & Sons, 3rd edition, 2003, ISBN: 9780470539675. |
|  | Green, M.A., et al. Solar Cell Efficiency Tables (Version 30). 2007. Prog. Photo volt: Res. Appl. ISBN: 15:425-430. |

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**Mapping of Course Outcomes (CO) to Program Outcomes (PO)**

|  |  |
| --- | --- |
|  | Programme outcome  |
|  | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
| CO1 | M | M | M | M | M | L | M | H | M | M | L |
| CO2 | H | L | M | M | L | M | L | L | H | M | M |
| CO3 | M | M | L | H | H | M | L | M | L | M | M |
| CO4 | M | M | M | L | L | M | M | M | H | M | M |

**Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)**

|  |  |  |
| --- | --- | --- |
|  | **PSO1** | **PSO2** |
| **CO1** | **H** | **M** |
| **CO2** | **M** | **M** |
| **CO3** | **M** | **H** |
| **CO4** | **M** | **M** |