# Government College of Engineering,

# Chhatrapati Sambhajinagar

## (An Autonomous Institute of Government of Maharashtra)

**Station Road, Osmanpura, Chhatrapati Sambhaji Nagar – 431005 (M. S.)**

**Phone – (0240) 2366101, 2366111, Fax (0240) 2332835**

# Master of Technology

## Curriculum of M. Tech. in Electrical Machines and Drives

**Regular (2026-27 Onwards)**

## Vision of the Institute

To be globally recognized leader in technical education through industry integration and societal wellbeing

## Missions of the Institute

1. To build career-ready graduates through multidisciplinary learning and industry-sync curricula

2. To promote ecosystem for cutting-edge research, patents, publications, IPR, innovation, technology transfer and entrepreneurship

3. To be a premier trusted partner of government allied bodies, industries, and society



Dr. N. R. Bhasme
Head, Electrical

Dr. Anil Karwankar
Dean , Academics

M.Tech. Electrical Power System Curriculum
With effect from Academic Year 2026–2027
*Approved in the 32nd Academic Council Meeting, dated 28th July 2026*

## Vision of the Electrical Engineering Department

To provide technical education in Electrical Engineering that empowers aspiring engineers from the region to become competitive, industry-ready & socially responsible

## Missions of the Electrical Engineering Department

- To impart strong fundamental technical knowledge through effective teaching and learning practices

- To encourage innovation, research aptitude & life-long learning

- To strengthen employability and industry readiness through industry-aligned trainings

- To inculcate professional and social ethics through value based activities and community engagement.

## Program Outcomes

- PO1: An ability to independently carry out research investigations to solve practical problems.
- PO2: An ability to write technical reports/artifacts.
- PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program, and it should be at the level higher than the requirements of the bachelor program.
- PO4: Ability to enhance experiential learning through project-based activities.
- PO5: Formulate and solve real life electrical problems by applying advanced methods.

# Curriculum

For Regular as well as for Working Professionals

## (With effect from academic year 2026-27 onwards)

### M.Tech. Programme Components

| **Components** | | **Total Credits** |
|---|---|---|
| Programme Core Course (PCC) | Program Courses | 20 |
| Programme Elective Course(PEC) | Program Electives | 10 |
| Open Elective (OEC) other than a particular program | Open Electives | 02 |
| Vocational and Skill Enhancement Course(VSE) | Skill Courses | 02 |
| Ability Enhancement Course (AEC) Technical Presentation | Humanities Social Science and Management(HSSM) | 02 |
| Entrepreneurship / Economics/ Management Courses (EEM) | | 02 |
| Indian Knowledge System(IKS) | | 02 |
| Research Methodology(RMC) | Experiential Learning Courses | 02 |
| Dissertation / Project / Internship (DIS/INT) | | 20 |
| Co-curricular Courses(CCC) | Liberal Learning Courses | Audit |
| | **Total Credits** | 62 |

**Department of Electrical Engineering**

Teaching and Evaluation Scheme for NEP Compliant Curriculum

**M. Tech. (Electrical Power Systems) Full Time**

**(From 2026-2027 onwards)**

**Semester I**

| Sr. No. | Category | Course Code | Courses | Scheme of Teaching (Hrs/Week) | | | Total Credits | Scheme of Evaluation(Marks) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | Theory , Practical | | | | Total |
| | | | | | | | | ISE I | ISE II | ISE III | ESE | |
| 1 | PCC | EEPCC5101 | Power System Planning Operation & Control | 3 | - | - | 3 | 20 | - | 20 | 60 | 100 |
| 2 | PCC | EEPCC5102 | Electrical Machine Modeling and Analysis | 3 | - | - | 3 | 20 | - | 20 | 60 | 100 |
| 3 | PCC | EEPCC5103 | Lab - Power Engineering | - | - | 2 | 1 | - | - | 25 | - | 25 |
| 4 | PCC | EEPCC5104 | Digital Protection of Power Systems | 3 | - | - | 3 | 20 | - | 20 | 60 | 100 |
| 5 | PEC-I | | | 3 | - | - | 3 | 20 | - | 20 | 60 | 100 |
| 6 | PEC -II | | | 3 | - | - | 3 | 20 | - | 20 | 60 | 100 |
| 7 | VSE | EEVSE5101 | Lab Simulation | - | - | 4 | 2 | - | - | 50 | - | 50 |
| 8 | RMC | MERMC5002 | Research Methodology | 2 | - | - | 2 | 10 | 10 | 0 | 30 | 50 |
| 9 | CCC (Audit Course) | EECCC5101 | Stress Management Through Yoga | - | - | 2 | - | - | - | - | - | 00 |
| | | | Total of Semester I | 17 | - | 8 | 20 | 110 | 10 | 175 | 330 | 625 |

**List of Program Electives in Semester I**

| | ***List of Program Electives I, II** | | |
|---|---|---|---|
| **Course Codes** | **Program Electives** | **Course Codes** | **Program Electives** |
| **EEPEC5101** | **Smart Grid Technology** | EEPCC6101 | Electric Vehicles & HEV |
| **EEPEC5102** | **Restructured Power Systems** | EEPEC6102 | Embedded Systems |
| **EEPEC5103** | **Electrical Power Distribution Systems** | EEPEC6103 | Electromagnetic Interference |
| | | EEPCC6104 | Advanced Power Electronics |

- Student can choose any NPTEL course from program domain

## Semester II

| Sr. No. | Category | Course Code | Subject | Scheme of Teaching (Hrs/Week) | | | Total Credits | Scheme of Evaluation(Marks) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | Theory | | | | Total |
| | | | | | | | | ISE I | ISE II | ISE III | ESE | |
| 1 | PCC | EEPCC5110 | Power Systems Dynamics and Stability | 3 | - | - | 3 | 20 | - | 20 | 60 | 100 |
| 3 | PCC | EEPCC5111 | HVDC & FACTs | 4 | - | - | 4 | 20 | - | 20 | 60 | 100 |
| 4 | PEC III | | | 3 | - | - | 3 | 20 | - | 20 | 60 | 100 |
| 5 | PEC IV | | | 3 | - | - | 3 | 20 | - | 20 | 60 | 100 |
| 6 | PCC | EEPCC5112 | Lab Power Quality and Mitigation | - | - | 2 | 1 | - | - | 25 | - | 25 |
| 7 | OEC | EEOEC5101 | Data Science for Engineering Applications | 2 | - | - | 2 | 10 | 10 | 0 | 30 | 50 |
| 8 | AEC | EEAEC5110 | Lab Software skills | - | - | 4 | 2 | - | - | 50 | - | 50 |
| 9 | DIS | EEDIS5120 | Dissertation - I | - | - | 4 | 2 | - | - | 50 | 50 | 100 |
| | | | **Total Semester II** | 15 | - | 10 | **20** | 90 | 10 | 205 | 320 | 625 |

### List of Program Electives in Semester II

| *List of Program Electives III, IV | | | |
|---|---|---|---|
| **Course Codes** | **Program Electives** | **Course Codes** | **Program Electives** |
| **EEPEC5112** | **Machine Learning & Applications** | EEPEC6110 | Reliability and Condition Monitoring |
| **EEPEC5113** | **Optimization Techniques** | EEPCC6111 | Advanced Control Systems |
| **EEPEC5114** | **Power Quality and Mitigation** | EEPCC6112 | Control of Modern Electrical Drives |
| **EEPEC5015** | **NPTEL Course** | EEPEC6113 | Energy Storage Systems |
| • Student can choose any NPTEL course from program domain | | | |



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Head, Electrical

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Dean , Academics

**Open Elective** Equivalent online courses (NPTEL/SWAYAM/MOOC/COURSERA/OTHERS) will be offered and shall be approved by BoS Chairman**

| Sr No. | Open Elective Course | Course Offering Department |
|---|---|---|
| 1 | AMOEC5214 - Basics of Finite Element Analysis | Applied Mechanics |
| 2 | CSOEC5102 - Professional Ethics & Cyber Law | Computer Science & Engineering |
| 3 | CEOEC5003 – Disaster Management | Civil Engineering |
| 4 | MEOEC5004 - Robotics (Not for Mechanical PG Students) | Mechanical Engineering |
| 5 | EEOEC5001 – Data Science for Engineering Applications | Electrical Engineering |
| 6 | ECOEC5006 – Artificial Intelligence of Things | Electronics & Telecommunication |

**Semester III**

| Sr. No. | Category | Course Code | Subject | Scheme of Teaching (Hrs/Week) | | | Total Credits | Scheme of Evaluation(Marks) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | Theory | | | Total |
| | | | | | | | | ISE I | ISE III | ESE | |
| 1 | EEM | EEEEM5101 | Energy Audit & Management | 2 | - | - | 2 | 10 | 10 | 30 | 50 |
| 2 | IKS | EEIKS5101 | Vedic Approach to Mathematics | 2 | - | - | 2 | 10 | 10 | 30 | 50 |
| 3 | DIS | EEDIS5120 | Dissertation – II | - | - | 16 | 8 | - | 50 | 50 | 100 |
| 4 | | | | | | | | | | | |
| | | | **Total Semester III** | **4** | **-** | **18** | **12** | **20** | **70** | **110** | **200** |

**HSSM: - Entrepreneurship / Economics / Management Course**

| Sr. No. | Open Elective – II Course | Course Offering Department |
|---|---|---|
| 1 | CEEEM6001 –Ancient Water Management Systems | Civil Engineering |
| | MEEEM6001 – Entrepreneurship Development | Mechanical Engineering |
| 2 | EEEEM 5101 – Energy Audit & Management | Electrical Engineering |
| 3 | MEEEM6003 – Industrial Management | Mechanical Engineering |
| 4 | ECEEM6004- AI Governance & Ethics | Electronics & Telecommunication |

## Semester IV

| Sr. No. | Category | Course Code | Subject | Scheme of Teaching (Hrs/Week) | | | Total Credits | Scheme of Evaluation(Marks) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | Theory | | | Total |
| | | | | | | | | ISE I | ISE III | ESE | |
| 1 | INT | EEINT5101 | Industrial Training/Internship | - | - | - | 10 | - | 50 | 50 | 100 |
| | | | Total Semester IV | - | - | - | 10 | - | 50 | 50 | 100 |

**Semester I**

| EEPCC5101: Power System Planning, Operation & Control | |
|---|---|
| **Teaching Scheme**<br>Lectures: 3 Hrs/Week<br>Tutorial: 0 Hr/Week<br>Credits: 03 | **Examination Scheme**<br>ISE I :20 Marks<br>ISE III : 20 Marks<br>End-Semester Examination : 60 Marks |

**Course Description**: This course covers aspects of planning, operation and control of power systems.

**Course Objectives:** The objectives of the course are to introduce & explain:

1. Planning & forecasting of loads
2. Methods to determine transmission loss
3. Load frequency control.
4. Real & reactive power control
5. Operation & control of interconnected power systems

**Course Outcomes:** After completing the course, students will able to:

| | |
|---|---|
| CO1 | Explain load forecasting and load frequency control |
| CO2 | Analyze various methods of real & reactive power control |
| CO3 | Analyze various methods for economic operation of power system |
| CO4 | Apply unit commitment for reliable operation of power system |
| CO5 | Explain computer control & Low carbon operations in power system |

**Detailed Syllabus:**

| | |
|---|---|
| **Unit 1** | **Introduction & Load frequency Control**<br>Objectives of planning-Long and short term planning, Load forecasting, characteristics of loads, methodology of forecasting-energy forecasting, peak demand forecasting, total forecasting, annual and monthly peak demand forecasting<br>Basics of speed governing mechanism and modeling -speed- load characteristics, load sharing between two synchronous machines in parallel. Control area concept. Load Frequency Control of a single area system. Static and dynamic analysis of uncontrolled and controlled cases. Integration of economic dispatch control with LFC. Two- area system |
| **Unit 2** | **Reactive Power and Voltage Control:**<br>Basics of reactive power control, Excitation, systems, modeling. Static and dynamic analysis: stability compensation generation and absorption of reactive power. Methods of voltage control. MVAR injection of switched capacitors, series and shunt compensation, Load compensation and system compensation, FACT controllers |
| **Unit 3** | **Economic Operation:**<br>Statement of economic dispatch problem – cost of generation-Incremental cost curve - co-ordination equations without loss and with loss, solution by direct method and λ-iteration method. Economic Aspects of Power Generation: Load curve, load duration and integrated load duration curves – load demand, diversity, capacity, utilization and plant use factors |

| | |
|---|---|
| **Unit 4** | **Unit Commitment**:<br>Statement of Unit Commitment problem-constraints, spinning reserve, thermal unit constraints, hydro constraints, fuel constraints and other constraints. Solution methods -Priority list methods - forward dynamic programming approach. Numerical problems on priority-list method using full- load average production cost and Forward DP method. |
| **Unit 5** | **Computer control & Low carbon operations:**<br>Need for computer control of power systems. Concept of energy control centre (or) load dispatch centre and the functions- SCADA and EMS functions.<br>Low carbon power system operations, emission dispatch model, emission reduction policies , emission trading & deregulation of power sector |

**Text and Reference Books**


1. D.P. Kothari and I.J. Nagrath, 'Modern Power System Analysis', Third Edition, Tata McGraw Hill Publishing Company Limited, New Delhi, 2003.
2. Olle. I. Elgerd, 'Electric Energy Systems Theory – An Introduction', Tata McGraw Hill,Publishing Company Ltd, New Delhi, 30th reprint,2007.
3. P. Kundur, Neal J. Balu, 'Power System Stability & Control', IEEE, 1998.
4. Chakrabarti & Haldar, "Power System Analysis: Operation and Control", PHI India, 2004 Edition.
5. C.L.Wadhwa, 'Power System Analysis', New Age International- 6th Edition, 2010,
6. Robert Miller, James Malinowski, 'Power System Operation', Tata McGraw Hill Publishing Company Ltd, New Delhi, 3E, JUN-09.


**ISE III Assessment:** It is based on any one or combination of the following.

1. Presentation on latest topics/Real life problems related with the subject
2. Simulations problems
3. Quiz
4. MCQ

**Sample Assessment Pattern:**

| Assessment Pattern Level No. | Knowledge Level | ISE I Test | ISE III Teachers Assessment | End Semester Examination |
|---|---|---|---|---|
| K3 | Apply | 05 | 10 | 20 |
| K4 | Analyze | 10 | 10 | 20 |
| K5 | Evaluate | 05 | | 20 |
| K6 | Create | - | - | - |
| **Total Marks: 100** | | 20 | 20 | 60 |

**Sample Assessment table**:

| Assessment Tool | K2+ K3 | K2+ K3 | K2+ K3 | K2+ K3 | K2+K3 |
|---|---|---|---|---|---|
| | CO1 | CO2 | CO3 | CO4 | CO5 |
| ISE I Test (20 Marks) | 10 | 10 | | | |
| ISE III Assessment (20 Marks) | | | | 10 | 10 |
| ESE Assessment (60 Marks) | 12 | 12 | 12 | 12 | 12 |

**Designed by**
**Prof. M.R.Bachawad**

| EEPCC5102 : Electrical Machine Modeling and Analysis | | |
|---|---|---|
| **Teaching Scheme** | **Examination Scheme** | |
| Lectures: 03 Hrs/Week | ISE I | : 20 Marks |
| Tutorials: 0 Hrs/Week | ISE III | : 20 Marks |
| Credits:03 | End Semester Exam | : 60 Marks |

**Course Description**:
Electrical Machines modeling and Analysis is a one-semester course where students can opt this course as a professional elective.

**Course Objective:** The objectives of the course are to master the various fundamentals, machine design, Machine modeling of various types of electrical machines. This will help you to gain knowledge and to do research in the area of electrical machine modeling.

The main objective of the course is to:

1. understand the concepts of generalized theory of electrical machines.
2. model the electrical machines with voltage, and torque equations.
3. analyze the steady state and transient behavior of the electrical machines.
4. understand the dynamic behavior of the DC/AC, special machines.
5. analyze behavior of different types of machines such as sudden application of loads, short circuit etc.

**Course Outcomes:** After completing the course, students will be able to:

| | |
|---|---|
| CO1 | explain the concepts of the rotating machines |
| CO2 | represent and distinguish the different transformations of the systems using transformation techniques |
| CO3 | analyze and model DC machine in state space |
| CO4 | analyze and model three phase Induction Motor |
| CO5 | analyze and model of synchronous machine, BLDC & PMSM machines |

**Detailed Syllabus:**

| | |
|---|---|
| **Unit 1** | **Basic concepts of Modeling:**<br>Basic Principles of Electrical Machine Analysis, Need of modeling, Introduction to modeling of electrical machines |
| **Unit 2** | **Concept of transformation:**<br>Commonly Used Reference Frames, change of variables & m/c variables and transform variables for arbitrary reference frames. Stationary Circuit Variables Transformed to the Arbitrary Reference Frame, Transformation Between Reference Frames, and Transformation of a Balanced Set, Balanced Steady State Phasor Relationships , And Balanced Steady State Voltage Equations |
| **Unit 3** | **Modeling of Direct-Current Machine:**<br>Voltage and Torque Equations in Machine Variables, Mathematical model of separately excited D.C motor – Steady State analysis-Transient State analysis, Application to D.C. machine for steady state and transient analysis |

| | |
|---|---|
| **Unit 4** | **Modeling of Three phase Induction Machines:**<br>Theory of symmetrical Induction Machines: Voltage and torque in machine variables, model for a symmetrical induction machine, Voltage and torque equation in arbitrary reference frame variables, analysis of steady- state operation, Modeling of 3 phase Induction Motor, Derivation of dq0, Voltage, torque equations, Equivalent circuit, Steady state analysis, Dynamic performance during sudden changes in load torque and three phase fault at the machine terminals. |
| **Unit 5** | **Modeling of Three phase Synchronous Machine:**<br>Equations in arbitrary reference frame, Park's transformation, Derivation of *dq0* model for a salient pole synchronous machine with damper windings, Torque expression of a salient pole synchronous machine with damper windings and identification of various components.<br>**Modeling Permanent Magnet Synchronous Machine:**<br>Introduction, Types of Permanent Magnet Synchronous Machines, PMAC & PMDC(BLDC) ,Voltage and torque equations in machine variables, voltage and torque equations in rotor reference frame variables |

**Text and Reference Books:**


1. P.C. Krause, "Analysis of Electric Machinery, McGraw Hill", NY, 1987
2. C.V. Jones, "The unified Theory of Electrical Machines", Butterworth,-London, 1967
3. Stevenson, "Power System Analysis", McGraw Hill, NY
4. Dhar R.N., "Computer Aided Power System Operation and Analysis", Tata McGraw Hill
5. P.S. Bhimbra, "The Generalised Theory of Electrical Machines", Tata McGraw Hill
6. B. Adkins & R. G. Harley, "The General theory of AC Machines", Tata McGraw Hill
7. R. Krishnan, "Electric Motor Drives – Modeling, Analysis and Control", PHI Learning Private Limited, New Delhi, 2011.


**ISE III Assessment:** Teachers Assessment of 20 marks is based on **attendance** of the student and one of the / or combination of few of following. However, the course coordinator has to announce assessment components at the beginning of the course.

1. Presentation on latest topics/Real life problems related with the subject
2. Problems based on GATE questions
3. Simulations problems
4. Quiz

**Sample Assessment Pattern:**

| **Assessment Pattern Level No.** | **Knowledge Level** | **ISE I Test** | **ISE III Teachers Assessment** | **End Semester Examination** |
|---|---|---|---|---|
| K3 | Apply | 05 | 10 | 20 |
| K4 | Analyze | 10 | 10 | 20 |
| K5 | Evaluate | 05 | | 20 |
| K6 | Create | - | - | - |
| **Total Marks: 100** | | 20 | 20 | 60 |

**Sample Assessment table**

| Assessment Tool | K2+ K3 | K2+ K3 | K2+ K3 | K2+ K3 | K2+K3 |
|---|---|---|---|---|---|
| | CO1 | CO2 | CO3 | CO4 | CO5 |
| ISE I Test (20 Marks) | 10 | 10 | | | |
| ISE III Assessment (20 Marks) | | | | 10 | 10 |
| ESE Assessment (60 Marks) | 12 | 12 | 12 | 12 | 12 |

**Teaching Strategies:**

The teaching strategy planned through the lectures, and team based home works. Exercises assigned weekly to stimulate the students to actively use and revise the learned concepts, which also help the students to express their way of solving the problems fluently in written form. Most critical concepts and mistakes emphasized

**Designed by**
**Dr. Sandhya Kulkarni**

| EEPCC5103: Lab Power Engineering | |
|---|---|
| **Teaching Scheme**<br>Practical : 02 Hrs/Week<br>Credits : 01 | **Examination Scheme**<br>ISE III Term Work : 25 Marks<br>Total : 25 Marks |

Term Work shall consist of record of minimum twelve experiment/assignment using engineering computation software such as MATLAB, PSCAD, ETAP with moderate to high complexity.

Following is the list of experiments is just a guide line (Hardware and Software base)

1. Plot I-V and P-V characteristics of single Solar PV Module with radiation and temperature changing effects
2. Plot I-V and P-V characteristics with series and parallel combination of Solar PV modules.
3. Study effect of shading on output power of Solar PV Module
4. Measure output power of solar PV system with effect of tilt angle
5. Plot charging and discharging characteristics of battery
6. Measure performance parameters of DC load system with and without battery (with variable rated capacity system) in Solar PV stand-alone system.
7. Measure performance parameters of AC load system with and without battery in Solar stand-alone PV system.
8. Measure performance parameters of Combine AC and DC load system with and without battery in Solar stand-alone PV system.
9. Study of biomass plant
10. Identify and measure the parameters of a solar PV Module at Specific location
11. Measure the spectral response of a solar cell and Calculate quantum efficiency
12. Study solar resource assessment station and record associated parameters
13. Simulate characteristics of fuel cell using electrical software
14. Simulate operation of wind turbine and measure associated parameters using electrical software
15. Study of Tri-brid system

| EEPCC5104: Digital Protection of Power Systems | |
|---|---|
| **Teaching Scheme**<br>Lectures: 3 Hrs/Week<br>Tutorial: 0 Hr/Week<br>Credits : 03 | **Examination Scheme**<br>ISE I : 20 Marks<br>ISE III : 20 Marks<br>End Semester Exam : 60 Marks |

**Course Description:**

This course is a one-semester course as a mandatory course. It is a course related to use of digital signal processing and other new technologies for power system protection.

**Course Objective:**

The objectives of the course are to introduce & explain:

1. Advantages of digital relays over conventional relay
2. Understand the concepts related to digital signal processing
3. Develop decision making algorithms for protective relays
4. Design and simulate over current, distance and differential protection schemes for power systems.
5. Apply new technologies for power system protection

**Course Outcomes:** After completing the course, students will be able to:

| | |
|---|---|
| CO1 | Recognize the advantages of digital relays over conventional relay |
| CO2 | Apply the suitable signal processing techniques for protection |
| CO3 | Understand the adaptive criterion for relay decision making |
| CO4 | Develop the digital protection systems for Transformer and Transmission line |
| CO5 | Identify the new developments in protective relaying and applications. |

**Detailed Syllabus:**

| | |
|---|---|
| **Unit 1** | Overview of Static relays, Transmission line protection, Transformer protection, Need for digital protection<br>Digital Relays- Basic elements of a digital relay and their functions, signal conditioning subsystem, conversion subsystem, digital relay subsystem |
| **Unit 2** | Signal processing techniques– Sinusoidal based algorithms, Fourier analysis based algorithms, Least squares based algorithm, Discrete Fourier Transforms, Wavelet Transforms, Kalman Filtering |
| **Unit 3** | Travelling Wave Protection scheme, Digital Protection of Transformers, Infinite Impulse Response Filters, Finite Impulse Response filters<br>Correction of errors introduced by Instrument Transformers- PTs and CTs, detection of unsaturated fragment of wave shape, CT saturation correction procedure |
| **Unit 4** | Decision making in Protective Relays – Deterministic decision making, Statistical Hypothesis testing, Decision making with multiple criteria, Adaptive decision schemes, Adaptive Differential protective scheme |
| **Unit 5** | Applications of Fuzzy Logic and ANN for power system protection, Fault location algorithm, Wide Area Monitoring and Protection |

**Text and Reference Books**

1. Computer Relaying for Power Systems, A.G.Phadke, James S.Thorp, John-Wiley and sons, 2009, 2/e.
2. Digital Signal Processing in Power System Protection and Control, Waldemar Rebizant, Janusz Szafran, Andrzej Wiszniewski, Springer Publication, 2011, 1/e.
3. Digital Protection for Power Systems, A.T.Johns and S.K.Salman, IEE Power Series 15, 1997.
4. Digital Power System Protection, Singh, Prentice-Hall of India Pvt. Limited, 2007, 1/e

1. Understanding Digital Signal Processing, Orhan Gazi, Springer, 2017, 2/e
2. Fundamentals of Power System Protection, Paithankar Y.G, PHI, 2010, 2/e

Online Resources:

1. https://onlinecourses.nptel.ac.in/noc20_ee73/preview
2. NPTEL :: Electrical Engineering - Power System Protection
3. NPTEL :: Electrical Engineering - NOC:Power System Protection and Switchgear

**ISE III Assessment:** Teachers Assessment of 20 marks is based on **attendance** of the student and one of the / or combination of few of following.

1. Presentation on latest topics/Real life problems related with the subject
2. Simulations problems
3. Quiz
4. MCQ

**Assessment Pattern:**

| **Assessment Pattern Level No.** | **Knowledge Level** | **ISE I Test** | **ISE III Teachers Assessment** | **End Semester Examination** |
|---|---|---|---|---|
| K3 | Apply | 05 | 10 | 20 |
| K4 | Analyze | 10 | 10 | 20 |
| K5 | Evaluate | 05 | | 20 |
| K6 | Create | - | - | - |
| **Total Marks: 100** | | 20 | 20 | 60 |

**Assessment table**:

| Assessment Tool | K2+ K3 | K2+ K3 | K2+ K3 | K2+ K3 | K2+K3 |
|---|---|---|---|---|---|
| | CO1 | CO2 | CO3 | CO4 | CO5 |
| ISE I Test (20 Marks) | 10 | 10 | | | |
| ISE III Assessment (20 Marks) | | | | 10 | 10 |
| ESE Assessment (60 Marks) | 12 | 12 | 12 | 12 | 12 |

Designed by
Dr S P Ghanegaonkar

| EEVSE5101: Lab Simulation | |
|---|---|
| **Teaching Scheme**<br>Practicals: 4 Hrs/Week<br>Credits : 02 | **Examination Scheme**<br>Term Work (ISE III) : 50 Marks<br>**Total Marks 50 Marks** |

Students should perform total **Fourteen** experiments.

**Any 6 from following-**
1. Generalized program to determine Ybus of given network.
2. Generalized program to determine load flow of a given network using G-S method.
3. Generalized program to determine load flow of a given network using the N-R method.
4. Generalized program to determine load flow of a given network using FDLF method.
5. Formation of YBUS using two dimensional arrays by inspection method
6. Formation of YBUS using Sparsity Technique
7. Power system load flow of IEEE 6 BUS

**Any 4 from following-**
1. Familiarization with various features of the Scilab / MATLAB/Simulink environment.
2. Demonstrating the phenomenon of aliasing due to under-sampling.
3. Implementation of algorithms based on undistorted sine wave approximation with Sample and its derivative
4. Implementation of algorithms based on undistorted sine wave approximation with First and second derivative technique
5. Implementation of Differential Equation Algorithm(DEA) by Numerical differentiation
6. Implementation of Sachdev's Least Square Error (LSQ) Algorithm.
7. Implementation of Fourier algorithms using DFT

**Any 4 from following-**
1. Simulation of DC-DC converters: (i) Buck Converter Boost Converter, and Buck Boost converter.
2. Simulation of single phase and three-phase controlled rectifiers with different loads.
3. Simulation of single phase inverter: (i) Square wave, (ii) Quasi Square wave, (iii) Selective Harmonic Elimination, and (iv) Sine PWM.
4. Simulation of three-phase inverter: (i) 120 Degree conduction, (ii) 180 Degree conduction
5. Simulation of Multi-pulse converter: (i) 12-pulse
6. Simulation of Multi-level inverter: (i) 3-Level
7. Simulation of CUK Converter, Fly back converter, Push-Pull converter and Forward Converter.

**List of   Program Electives in Semester I**

| | *List of  Program Electives I, II | | |
|---|---|---|---|
| **Course Codes** | **Program Electives** | **Course Codes** | **Program Electives** |
| **EEPEC5101** | **Smart Grid Technology** | EEPCC6101 | Electric Vehicles & HEV |
| **EEPEC5102** | **Restructured Power Systems** | EEPEC6102 | Embedded Systems |
| **EEPEC5103** | **Electrical Power Distribution** | EEPEC6103 | Electromagnetic Interference Techniques |
| **EEPEC5004** | **NPTEL Course** | **EEPEC6104** | **Advanced Power Electronics** |

| EEPEC5101 : Smart Grid Technology | |
|---|---|
| **Teaching Scheme**<br>Lectures: 3 Hrs/Week<br>Tutorial: 0 Hrs/Week<br>Credits : 03 | **Examination Scheme**<br>ISE I : 20 Marks<br>ISE III : 20 Marks<br>End-Semester Examination : 60 Marks |

**Course Description**: This course introduces the concepts of smart grid technology & covers the various aspects of smart grid.

**Course Objectives:**

The objectives of the course are to:

1. Understand concept of smart grid and its advantages over conventional grid
2. Know smart metering techniques
3. Learn wide area measurement techniques
4. Understand concept of power quality issues in Smart grid
5. Appreciate problems associated with integration of distributed generation & its solution through smart grid

**Course Outcomes:**

After completing the course, students will able to:

| | |
|---|---|
| CO1 | Differentiate between smart grid & conventional grid |
| CO2 | Explain smart grid technologies |
| CO3 | Explain the concept of micro grid & issues of micro grid interconnection |
| CO4 | Identify the power quality issues in Smart grid |
| CO5 | Explain different Communication Technology for Smart Grid |

**Detailed Syllabus:**

| | |
|---|---|
| **Unit 1** | **Introduction to Smart Grid:**<br>Working definitions of Smart Grid and Associated Concepts, Smart Grid Functions, Traditional Power Grid and Smart Grid, New Technologies for Smart Grid, Advantages Indian Smart Grid, Key Challenges for Smart Grid, International policies in Smart Grid. Smart Grid Architecture: Components and Architecture of Smart Grid Design. Review of the proposed architectures for Smart Grid |
| **Unit 2** | **Tools and Techniques for Smart Grid:**<br>The fundamental components of Smart Grid designs, Transmission and substation Automation, Distribution Automation, Renewable Integration<br>Smart Meters, Real Time Pricing, Smart Appliances, Automatic Meter Reading (AMR), Smart integration of energy resources, Renewable, intermittent power sources, Energy Storage |
| **Unit 3** | **Distribution Generation Technologies:**<br>Introduction to Renewable Energy Technologies, Micro grids- Concept and need, issues of interconnection, Storage Technologies, Electric Vehicles and plug-in hybrids. Environmental impact and Climate Change Economic Issues |
| **Unit 4** | **Communication Technologies and Smart Grid:**<br>Introduction to Communication Technology, Synchro-Phasor Measurement Units (PMUs) Wide Area Measurement Systems (WAMS)- Introduction to Internet of things (IOT)- Applications of IOT in Smart Grid<br>Home Area Network (HAN), Neighborhood Area Network (NAN), Advanced Metering Infrastructure (AMI), CLOUD Computing, Cyber Security for Smart Grid |

| Unit 5 | **Control of Smart Power Grid System:** Load Frequency Control (LFC) in Micro Grid System Voltage Control in Micro Grid System protection of micro grid, Reactive Power Control in Smart Grid. Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid. |
|---|---|

**Text and Reference Books**


1. Ali Keyhani, Mohammad N. Marwali, Min Dai "Integration of Green and Renewable Energy in Electric Power Systems", Wiley
2. Clark W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response", CRC Press
3. JanakaEkanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", Wiley
4. Jean Claude Sabonnadiere, NouredineHadjsaid, "Smart Grids", Wiley Blackwell
5. Tony Flick and Justin Morehouse, "Securing the Smart Grid", Elsevier Inc. (ISBN: 978-1-59749-570-7)


**ISE III Assessment:** Teachers Assessment of 20 marks is based on one or combination of few of following.

1. Presentation on latest topics/Real life problems related with the subject
2. Simulations problems
3. Quiz
4. MCQ

**Assessment Pattern:**

| **Assessment Pattern Level No.** | **Knowledge Level** | **ISE I Test** | **ISE III Teachers Assessment** | **End Semester Examination** |
|---|---|---|---|---|
| K3 | Apply | 05 | 10 | 20 |
| K4 | Analyze | 10 | 10 | 20 |
| K5 | Evaluate | 05 | | 20 |
| K6 | Create | - | - | - |
| **Total Marks: 100** | | 20 | 20 | 60 |

**Assessment Table** :

| Assessment Tool | K2+ K3 | K2+ K3 | K2+ K3 | K2+ K3 | K2+K3 |
|---|---|---|---|---|---|
| | CO1 | CO2 | CO3 | CO4 | CO5 |
| ISE I Test (20 Marks) | 10 | 10 | | | |
| ISE III Assessment (20 Marks) | | | | 10 | 10 |
| ESE Assessment (60 Marks) | 12 | 12 | 12 | 12 | 12 |

**Designed by**
**Dr. S.P Ghanegaonkar**

| EEPEC5102 : Restructured Power Systems | |
|---|---|
| **Teaching Scheme** | **Examination Scheme** |
| Lectures: 3 Hrs/Week | ISE I : 20 Marks |
| Tutorial: 0 Hr/Week | ISE III : 20 Marks |
| Credits: 3 | End-Semester Examination : 60 Marks |

**Course Description**: This is an elective course & covers the different aspects of power systems in restructured environment.

**Course Objectives:**

The objectives of the course are to learn:

1. Basic aspects of power system restructuring.
2. Different models of deregulated power systems.
3. Different methods to determine transmission pricing.
4. Available transfer capability.
5. Regulatory issues involved in the deregulation of the power industry.

**Course Outcomes:** After completing the course, students will able to:

| | |
|---|---|
| CO1 | Explain basic aspects of power system restructuring. |
| CO2 | Explain different models of deregulated power systems. |
| CO3 | Explain different methods to determine transmission pricing. |
| CO4 | Determine available transfer capability. |
| CO5 | Explain Ancillary Services management in various markets & regulatory issues. |

**Detailed Syllabus:**

| | |
|---|---|
| **Unit 1** | **Introduction:**<br>Basic concept and definitions, privatization, restructuring, transmission open access, wheeling, deregulation, components of deregulated system, advantages of competitive system. |
| **Unit 2** | **Deregulation of Power Sector:**<br>Separation of ownership and operation, Deregulated models, pool model, pool and bilateral trade model, multilateral trade model. Competitive electricity market: Independent System Operator activities in pool market, Wholesale electricity market characteristics, central auction, single auction power pool, double auction power pool, market clearing and pricing, Market Power and its Mitigation Techniques, Bilateral trading, Ancillary services. |
| **Unit 3** | **Transmission Pricing:**<br>Marginal pricing of Electricity, nodal pricing, zonal pricing, embedded cost, Postage stamp method, Contract Path method, Boundary flow method, MW-mile method, MVA-mile method, Comparison of different methods. |
| **Unit 4** | **Congestion Management:**<br>Congestion management in normal operation, explanation with suitable example, total transfer capability (TTC), Available transfer capability (ATC), Different Experiences in deregulation: England and Wales, Norway, China, California, New Zealand and Indian power system. |
| **Unit 5** | **Ancillary Services and System Security in Deregulation:**<br>Classifications and definitions, AS management in various markets- country practices. Technical, economic, & regulatory issues involved in the deregulation of the power industry. |

**Text and Reference Books**

1. Loi Lei Lai, "Power System Restructuring and Deregulation", John Wiley & Sons Ltd.
2. Mohammad shahidehpour, M.alomoush, "Restructured power systems, operation, trading and volatility, ", CRC Press

**ISE III Assessment:** Teachers Assessment of 20 marks is based on **attendance** of the student and one of the / or combination of few of following.

1. Presentation on latest topics/Real life problems related with the subject
2. Simulations problems
3. Quiz
4. MCQ

**Sample Assessment Pattern:**

| **Assessment Pattern Level No.** | **Knowledge Level** | **ISE I Test** | **ISE III Teachers Assessment** | **End Semester Examination** |
|---|---|---|---|---|
| K3 | Apply | 05 | 10 | 20 |
| K4 | Analyze | 10 | 10 | 20 |
| K5 | Evaluate | 05 | | 20 |
| K6 | Create | - | - | - |
| **Total Marks: 100** | | 20 | 20 | 60 |

**Sample Assessment table**:

| Assessment Tool | K2+K3 | K2+K3 | K2+K3 | K2+K3 | K2+K3 |
|---|---|---|---|---|---|
| | C01 | C02 | C03 | CO4 | CO5 |
| ISE I Test (20 Marks) | 10 | 10 | | | |
| ISE III Assessment (20 Marks) | | | 5 | 5 | 10 |
| ESE Assessment (60 Marks) | 12 | 12 | 12 | 12 | 12 |

**Designed by Dr. V. A. Kulkarni**

| EEPEC5103: Electrical Power Distribution Systems | | |
|---|---|---|
| **Teaching Scheme** | **Examination Scheme** | |
| Lectures: 3 Hrs/Week | ISE I | : 20 Marks |
| Tutorial: 0 Hr/Week | ISE III | : 20 Marks |
| Credits : 03 | End Semester Exam | : 60 Marks |

**Course Description:** This introduces the basic concepts of electrical power distribution

**Course Objectives:** The objectives of the course are to give exposure to-

1. Distinguish between transmission, and distribution line and design the feeders
1. Design of distribution feeders and select appropriate substation location
3. Compute power loss and voltage drop of the feeders
4. Design protection of distribution systems
5. Apply voltage control techniques for power factor improvement

**Course Outcomes:**

After completing the course, students will able to:

| | |
|---|---|
| **CO1** | Understand the general concepts of distribution systems and difference between transmission systems and distribution systems |
| **CO2** | Design the distribution feeders and secondary distribution system and Identify and select appropriate sub–station location |
| **CO3** | Analyze a distribution system for voltage drop and power loss calculation |
| **CO4** | Explain faults on distribution systems and protective devices and its coordination for protection of distribution systems. |
| **CO5** | Analyze Voltage control and Power factor improvement procedures for distribution systems. |

**Detailed Syllabus:**

| | |
|---|---|
| **UNIT I** | **Introduction and General concepts**<br>Introduction to Distribution Systems: Load modeling and Characteristics- Coincidence factor, Contribution factor, loss factor, Relationship between the load factor and loss factor. Classification and characteristics of loads -Residential, commercial, Agricultural and Industrial. Distribution System Planning |
| **UNIT II** | **Distribution Feeders and Substations**<br>**Distribution Feeders:** Design Considerations of distribution feeders: Radial, loop and network types of primary feeders ,Voltage levels, Feeder loading, general circuit constants (A, B, C, D) to radial feeders,<br>Distribution Sub–Stations: Distribution substations –Bus schemes –comparison of switching schemes- Substation location and rating- Types of feeders – voltage levels |
| **UNIT III** | **Distribution System Analysis:**<br>**Voltage drop and power–loss calculations**: Derivation for voltage drop and power loss in lines-Uniformly distributed loads and non-uniformly distributed loads -Numerical problems-Three phase balanced primary lines. Power Flow Analysis of balanced distribution system<br>Distributed Generation in Distribution System: Need for Distributed generation, renewable sources in distributed generation, Power flow analysis with DGs, Concept of microgrid |
| **UNIT IV** | **Protective Devices & Coordination:** Objectives of Distribution system protection, Types of common faults and procedure for fault calculation<br>**Protective devices:** Principle of operation of fuses, circuit reclosers and line sectionalizers and circuit breakers.<br>**Coordination of Protective device**s: General coordination procedure |
| **UNIT V** | **Voltage control in Distribution systems**<br>Voltage Control in Distribution Systems: Effects of series and shunt capacitors – justification for capacitors – Procedure to determine optimum capacitor size and location. Voltage control – Application of shunt capacitance for loss reduction – Harmonics in the system – static VAR systems – loss reduction and voltage improvement. |

**Text Books and Reference Books**


1. Electrical Power Distribution Systems by V.Kamaraju, Right Publishers.
2. Electric Power Distribution – by A.S. Pabla, Tata McGraw–hill Publishing company, 4th edition, 1997.
3. Distribution System Modeling and Analysis by William H Kersting- CRC Press,Taylor and Francis Group 4th Edition, 2017

Turan Gonen, Electric Power Distribution System Engineering, CRC Press, 3rd Edition 2014.

**ISE III Assessment:** It is of 20 marks based on one of the / or combination of following,

1. Assignment , 2. MCQ

**Sample Assessment Pattern:**

| **Assessment Pattern Level No.** | **Knowledge Level** | **ISE I Test** | **ISE III Assessment** | **End Semester Examination** |
|---|---|---|---|---|
| K3 | Apply | 05 | 10 | 20 |
| K4 | Analyze | 10 | 10 | 20 |
| K5 | Evaluate | 05 | | 20 |
| K6 | Create | - | - | - |
| **Total Marks: 100** | | 20 | 20 | 60 |

**Sample Assessment table**:

| Assessment Tool | K2+K3 | K2+K3 | K2+K3 | K2+K3 | K2+K3 |
|---|---|---|---|---|---|
| | C01 | C02 | C03 | CO4 | CO5 |
| ISE I Test (20 Marks) | 10 | 10 | | | |
| ISE III Assessment (20 Marks) | | | 5 | 5 | 10 |
| ESE Assessment (60 Marks) | 12 | 12 | 12 | 12 | 12 |

**Designed by**
**Dr. Sunanda Ghanegaonkar**

| EEPCC6101: Electric and Hybrid Electrical Vehicles | | | |
|---|---|---|---|
| **Teaching Scheme** | | **Examination Scheme** | |
| Lectures | : 03 Hrs/Week | ISE I | : 20 Marks |
| Tutorial | : 0 | ISE III | : 20 Marks |
| Total Credits | : 03 | End -Semester Exam | : 60 Marks |

**Course description**: This course introduces the fundamental concepts, principles, analysis and design of hybrid and electric vehicles. Various aspects of hybrid and electric vehicles such as their configuration, types of electric machines that can be used, energy storage devices, etc. will be covered in this course.

**Course Objectives:** The objectives of the course are to introduce and explain
The concepts of electrical vehicles and their operation.

1. The basic components of the EV and their design.
2. Power converters & energy storage devices for electrical vehicles

**Course Outcomes :** After completing the course, students will able to:

| | |
|---|---|
| CO1 | Explain the operation of electrical vehicles. |
| CO2 | Explain Power Converters for Electric and hybrid Vehicles |
| CO3 | Identify the Electrical Machines for Electric and hybrid Vehicles |
| CO4 | Design the components of the electrical vehicles. |
| CO5 | Describe different Energy Storage options for the Electric and hybrid Vehicles |

**Detailed Syllabus:**

| | |
|---|---|
| **Unit 1** | History of electric & hybrid vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Dynamics of the electric and hybrid electrical vehicles- motion and dynamic equation for vehicles, Vehicle Power Plant and Transmission Characteristics, Basic Architecture of Hybrid Drive Trains and Analysis of Series Drive Train, Power Flow in HEVs, Torque Coupling and Analysis of Parallel DriveTrain, Basic Architecture of Electric Drive Trains |
| **Unit 2** | Power Converters- DC-DC converters for EV and HEV applications, DC-AC converters in EV & HEV |
| **Unit 3** | AC Electrical Machines for hybrid and Electric Vehicles- Induction motors, Permanent Magnet Motors. SRM motors, their control and applications in EV/HEV |
| **Unit 4** | Design of Electrical EV/HEV – Principles, Drive cycles and its detail analysis, sizing of electrical machines. Different test bench setups for emulating EV on-road conditions. |
| **Unit 5** | Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices.<br>Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies. |

**Text and Reference Books**


1. James Larminie, John Lowry, "Electric Vehicle Technology Explained", WIELY USA, 2012.
2. Chris Mi, M. Abdul Masrur & David Wenzhong Gao , "Hybrid Electric Vehicles: Principles and Applications with practical perspective", WIELY, 2011
3. Electric Cars The Future is Now!: Your Guide to the Cars You Can Buy Now and What the Future Holds, by Arvids Linde, Veloce Publishing,2010.
4. Abu-Rub, Malinowski and Al-Haddad, "Power Electronics for renewable energy systems, transportation, Industrial Applications", WILEY, 2014.
5. Mehrdad Ehsani, Yimin Gao, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design", Second Edition (Power Electronics and Applications Series) by CRC Press, 2009
6. John Miller, " Propulsion Systems for Hybrid Vehicles," Institute of Electrical Engineers, UK, 2004
7. C.M. Jefferson & R.H. Barnard, " Hybrid Vehicle Propulsion," WIT Press, 2002
8. Iqbal Husain, "Electric and Hybrid Vehicles – Design Fundamentals," CRC Press, 2010
9. James Larminie and John Lowry, " Electric Vehicle Technology Explained, " Oxford Brookes University, Oxford, UK, 2003


**ISE III Assessment: It of** 20 marks and is based on one or combination of few of following. However, the course coordinator has to announce assessment components at the beginning of the course.

1. Presentation on latest topics/Real life problems related with the subject
2. MCQ
3. Simulations problems
4. Quiz

**Sample Assessment Pattern:**

| **Assessment Pattern Level No.** | **Knowledge Level** | **ISE I Test** | **ISE III Assessment** | **End Semester Examination** |
|---|---|---|---|---|
| K3 | Apply | 05 | 10 | 20 |
| K4 | Analyze | 10 | 10 | 20 |
| K5 | Evaluate | 05 | | 20 |
| K6 | Create | - | - | - |
| **Total Marks: 100** | | 20 | 20 | 60 |

**Sample Assessment Table**:

| Assessment Tool | K2+K3 | K2+K3 | K2+K3 | K2+K3 | K2+K3 |
|---|---|---|---|---|---|
| | C01 | C02 | C03 | CO4 | CO5 |
| ISE I Test (20 Marks) | 10 | 10 | | | |
| ISE III Assessment (20 Marks) | | | 5 | 5 | 10 |
| ESE Assessment (60 Marks) | 12 | 12 | 12 | 12 | 12 |

**Designed by Prof. S.P. Vasekar**

| EEPEC6102 Embedded Systems | |
|---|---|
| **Teaching Scheme** | **Examination Scheme** |
| Lectures : 3 Hrs/Week | ISE I : 20 Marks |
| Tutorial : 0 Hr/Week | ISE III : 20 Marks |
| Total Credits : 03 | End -Semester Exam : 60 Marks |

**Course Description:**

The course focuses on the concepts of Embedded platform, understand related programming PIC architecture and peripheral interfacing and develop the applications.

**Course Objectives:** The objectives of the course are to

1. Introduce to the architecture of embedded system
2. Explain various devices and communication system in network
3. Explain programming concept in C++
4. Explain real time operating concept
5. Explain the case studies in RTOS

**Unit wise Course Outcomes expected:**

At the end of the students will be able to

| | |
|---|---|
| **CO1** | Explain the embedded system concepts and architecture of embedded systems |
| **CO2** | Apply various signal conditioning devices for various applications using microcontroller |
| **CO3** | Test and debug peripherals and related applications in embedded platforms. |
| **CO4** | Write assembly language program for PIC microcontroller to interface peripherals |
| **CO5** | Debug and write the I/O and timers/counter programming |

**Detailed Syllabus:**

| | |
|---|---|
| **UNIT-I** | **Embedded system introduction:** Introduction to embedded system, embedded system architecture, classifications of embedded systems, challenges and design issues in embedded systems, fundamentals of embedded processor and microcontrollers, CISC vs. RISC, fundamentals of Vonneuman/Harvard architectures, types of microcontrollers, selection of microcontrollers. |
| **UNIT-II** | **Signal Conditioning:** Signal Conditioning & Various Signal Chain Elements, Critical Specifications, How to smartly choose elements from wide choice available in market. Various elements include OPAMPs, Comparators, Instrumentation OP AMPs, ADCs, DACs, DC-DC Converters, Isolators, Level Shifters, ESD Protection Devices. |

| | |
|---|---|
| **UNIT-III** | **Memory Systems:**<br>On Chip, Memory Subsystem, Bus Structure, Interfacing Protocol, Peripheral interfacing, Testing & Debugging, Power Management, Software for Embedded Systems, Design of Analog Signal Chain from Sensor to Processor with noise, power, signal bandwidth, Accuracy Considerations. Concurrent Programming. Real Time Scheduling, I/O Management, Embedded Operating Systems. RTOS, Developing Embedded Systems, Building Dependable Embedded Systems. |
| **UNIT-IV** | **PIC Architecture:**<br>Introduction to PIC microcontrollers, PIC architecture, comparison of PIC with other CISC and RISC based systems and microprocessors, memory mapping, assembly language programming, addressing modes, instruction set. |
| **UNIT-V** | **Applications:**<br>I/O Programming PIC I/O ports, I/O bit manipulation programming, timers/counters, programming to generate delay and waveform generation, I/O programming, LEDs, 7 segment LEDs, LCD and Keypad interfacing. |

**Text/References:**

1. Rajkamal, *"Embedded Systems Architecture, Programming and Design"*, TMH, 2003

2. WyneWoff "Principles of Embedded computing System Design", Morgan Koffman publication 2000

3. Steve Heath, *"Embedded Systems Design"*, Second Edition-2003, Butterworth-Heinemann.

4. David E.Simon, *"An Embedded Software Primer"*, Pearson Education Asia, First Indian Reprint 2000

5. Wayne Wolf, "Computers as Components; Principles of Embedded Computing System Design", Harcourt India, Morgan Kaufman Publishers

6. Chuck Helebuyck "Programming PIC microcontrollers with PIC basic"

7.Qing Li, "Real Time Concepts for Embedded Systems", Elsevier, 2011.

**ISE III Assessments:**

Teacher's Assessment based on one of the /or combinations of the few of the following.

1. Multiple choice question
2. PPT presentation
3. Assignments

**3. Assessment Pattern**

| Assessment Pattern Level No. | Knowledge Level | ISE 1 | ISE III Assignment | End Semester Examination |
|---|---|---|---|---|
| K3 | Apply | 10 | | 20 |
| K4 | Analyze | 10 | 10 | 20 |
| K5 | Evaluate | | 10 | 20 |
| **Total Marks 100** | | 20 | 20 | 60 |

## 4. Assessment table:

| Assessment Tool | | | | | |
|---|---|---|---|---|---|
| Course outcomes | CO1 | CO2 | CO3 | CO4 | CO5 |
| ISE I Test 20 Marks | 10 | 10 | | | |
| ISE III Assessment 20 marks | | | 10 | 05 | 05 |
| ESE Assessment 60 Marks | 12 | 12 | 12 | 12 | 12 |

**Designed by**
**Dr. S. S. Kulkarni**

| EEPEC6103: Electromagnetic Interference | | |
|---|---|---|
| **Teaching Scheme** | **Examination Scheme** | |
| Lectures: 3 Hrs/Week | ISE I Test | : 20 Marks |
| Tutorial: 0 Hr/Week | ISE III | : 20 Marks |
| Credits : 03 | End Semester Exam | : 60 Marks |

The students will be able to

| | |
|---|---|
| **CO1** | Recognize the sources of Conducted and radiated EMI in Power Electronic Converters and consumer appliances and suggest remedial measures to mitigate the problems |
| **CO2** | Assess the insertion loss and design EMI filters to reduce the loss |
| **CO3** | Design EMI filters, common-mode chokes and RC-snubber circuits measures to keep the interference within tolerable limits |
| **CO4** | Develop suitable techniques to mitigate EMI/EMC issues in power converters |

**Detailed Syllabus**

| | |
|---|---|
| **Unit I** | **Introduction:**<br>Sources of conducted and radiated EMI, EMC standardization and description, measuring instruments, conducted EMI references, EMI in power electronic equipment: EMI from power semiconductors circuits. |
| **Unit II** | **Noise suppression in relay systems:**<br>AC switching relays, shielded transformers, capacitor filters, EMI generation and reduction at source, influence of layout and control of parasites |
| **Unit III** | **EMI filter elements:** Capacitors, choke coils, resistors, EMI filter circuits. Ferrite breeds, feed through filters, bifilar wound choke filter, EMI filters at source, EMI filter at output<br>**EMI filter design for insertion loss:** Worst case insertion loss, design method for mismatched impedance condition and EMI filters with common mode choke-coils, IEC standards on EMI |
| **Unit IV** | **EMI in Switch Mode Power Supplies:**<br>EMI propagation modes, power line conducted-mode inference, safety regulations (ground return currents), Power line filters, suppressing EMI at sources, Line impedance stabilization network (LISN), line filter design, common-mode line filter inductors- design & example, series –mode inductors and problems, EMI measurements. |
| **Unit V** | **Faraday Screens for EMI prevention:**<br>As applied to switching devices, transformers faraday screen and safety screens, faraday screens on output components, reducing radiated EMI on gapped transformer cores, metal screens, electrostatic screens in transformers |

**Text Books & Reference Books:**

1. Electromagnetic Compatibility in Power Electronics, Laszlo Tihanyi, IEEE Press, 1995, 1st Edition.
2. Practical Design for Electromagnetic Compatibility, Ficchi, Rocco F., Hayden Book Co., 1981.
3. Handbook on Switch-Mode power supplies, Keith H Billings, Taylor Morey, McGraw-Hill, Publisher, 2011, 3rd Edition.
4. Switching Power Supply Design, Abraham I. Pressman, Keith Billings, Taylor Morey, McGraw Hill International, 2009, 3rd Edition.

Online Resources:

1. https://nptel.ac.in/courses/108/106/108106138/

**2. ISE III Assessment: It is** based on one or combinations of the following.

1. Multiple choice question
2. PPT presentation
3. Assignments

**Assessment Pattern:**

| **Assessment Pattern Level No.** | **Knowledge Level** | **ISE 1** | **ISE III Assignment** | **End Semester Examination** |
|---|---|---|---|---|
| K3 | Apply | 10 | | 20 |
| K4 | Analyze | 10 | 10 | 20 |
| K5 | Evaluate | | 10 | 20 |
| **Total Marks 100** | | 20 | 20 | 60 |

**3. Assessment table:**

| Assessment Tool | | | | | |
|---|---|---|---|---|---|
| Course outcomes | CO1 | CO2 | CO3 | CO4 | CO5 |
| ISE I Test 20 Marks | 10 | 10 | | | |
| ISE III Assessment 20 marks | | | 10 | 05 | 05 |
| ESE Assessment 60 Marks | 12 | 12 | 12 | 12 | 12 |

**Designed by:**
**Dr. S. S. Kulkarni**

| EEPCC6104 : Advanced Power Electronics | |
|---|---|
| **Teaching Scheme** | **Examination Scheme** |
| Lectures : 03 Hrs/Week | ISE I : 20 Marks |
| Tutorial : 0 Hrs/Week | ISE III : 20 Marks |
| Credits **:** 03 | End Semester Exam : 60 Marks |

**Course Description**:
Advanced Power Electronics is a one-semester course. It is an advanced course related to power electronics.

**Course Outcomes:**
After completing the course, students will able to:

| | |
|---|---|
| CO1 | Describe structure, characteristics, and applications of advanced power semiconductor devices |
| CO2 | Explain and analyze AC-AC converters |
| CO3 | Explain and analyze DC-AC converters and various control techniques |
| CO4 | Explain and analyze AC-AC converters |
| CO5 | Design of power converters components for various applications |

**Detailed Syllabus:**

| | |
|---|---|
| **UNIT-1** | Power Semiconductor Devices:<br>Structure, working principle, V-I characteristics, switching characteristics and protection circuits of Thyristors, TRIAC, GTOs, BJT, Power MOSFETS, SIT, IGBT, MCT, IGCT, PIC |
| **UNIT-2** | **AC-AC Converters:**<br>Single phase and three phase converter, dual converter, converter control, EMI and line power quality problems, phase-controlled cycloconverters, control of cycloconverters, matrix converters, high frequency cycloconverter |
| **UNIT-3** | **DC-DC converter:**<br>Power factor improvement techniques, Switch mode power converter, Buck, boost, buck boost, Cuk, Fly-back, Forward Converters, operation, modeling, and design of DC-DC converters, Different control strategies of DC-DC converters. Voltage mode and current mode control methods. |
| **UNIT-4** | **Inverters:**<br>PWM inverters, resonant pulse inverters, series and parallel resonant inverters, Voltage control of resonant inverters, Class E resonant inverter and rectifier, zero current and zero voltage switching resonant converters, resonant DC link inverters, multilevel inverters, diode clamped multilevel inverters, flying capacitor multilevel inverters, cascaded multilevel inverters, applications and features of multilevel inverters, DC link capacitors voltage balancing |

| | |
|---|---|
| **UNIT-5** | **Design of Power Converters Components:**<br>Design of magnetic components - design of transformer, design of inductor and current transformer - Selection of filter capacitors, Selection of ratings for devices, input filter design, Thermal design |

**Text and Reference Books:**

1. M. H. Rashid, “Power Electronics”, PHI publication
2. B.K. Bose, “Power Electronics and AC Drives”, Prentice Hall, 1986
3. Andrzej M. Trzynadlowski, “Introduction to Modern Power Electronics”, Wyley

**Teacher Assessment:**

Assessments will be based on any one or two of the following components -

1. Assignment
2. MCQ
3. PPT
4. Surprise Test

**Sample Assessment Pattern:**

| Assessment Pattern Level No. | Knowledge Level | ISE 1 | ISE III Assignment | End Semester Examination |
|---|---|---|---|---|
| K3 | Apply | 10 | | 20 |
| K4 | Analyze | 10 | 10 | 20 |
| K5 | Evaluate | | 10 | 20 |
| **Total Marks 100** | | 20 | 20 | 60 |

**Sample Assessment Table:**

| Assessment Tool | K2+K3 | K2+K3 | K2+K3 | K2+K3 | K2+K3 |
|---|---|---|---|---|---|
| | CO1 | CO2 | CO3 | CO4 | CO5 |
| Class Test (20 Marks) | 10 | 10 | | | |
| Teachers Assessment (20 Marks) | | 5 | 5 | 5 | 5 |
| ESE Assessment (60 Marks) | 12 | 12 | 12 | 12 | 12 |

**Designed by**
**Prof. S. S. Mopari**

| MERMC5001: Research Methodology (Offered by Mechanical Department | | |
|---|---|---|
| **Teaching Scheme** | **Examination Scheme** | |
| Lectures: 4 Hrs/Week | ISE I Test | : 10 Marks |
| Tutorial: 0 Hr/Week | ISE II | : 10 Marks |
| Credits : 04 | ISE III Assessment | : 00 Marks |
| | End Semester Exam | : 30 Marks |

After completing the course students will able to

| | |
|---|---|
| **CO1** | Develop the ability to comprehend core research concepts, define key elements like variables and hypotheses, and critically evaluate literature to identify research gaps. |
| **CO2** | Create well-structured research proposals that include clear research objectives, methods, and expected outcomes |
| **CO3** | . Create comprehensive research reports in diverse formats, such as academic papers, presentations, and technical reports. |

**Detailed Syllabus**

| | |
|---|---|
| Unit 1 | **Foundations and Methods of Research**<br>Meaning, objectives, significance of research; research approaches; research methods vs. methodology; scientific method; research process; criteria of good research; identifying and defining the research problem; selecting a research problem; research design; research plan; literature review; qualitative and quantitative research methods; historical, case study, ethnography, ex post facto, documentary and content analysis; survey methods (descriptive, normative, evaluative); field and laboratory experimental studies; characteristics, advantages, limitations, and implications of various research methods. |
| Unit 2 | **Data Collection and Data Analysis**<br>Concept of sampling; probability and non-probability sampling; sampling techniques and implications; tools of data collection—questionnaire, opinionnaire, observation, interviews, scales, and tests; designing and standardizing research tools; qualitative data analysis; quantitative data analysis; tabulation, graphs and charts; measures of central tendency and dispersion; hypothesis testing; parametric and non-parametric tests; validity, reliability, and delimitations of research findings. |
| Unit 3 | **Research Proposal, Interpretation and Report Writing**<br>Research proposal and its elements; formulation and definition of research problems; sources and criteria for selecting research problems; development of objectives; characteristics of objectives; formulation and application of hypotheses; interpretation of research findings; techniques of interpretation; research report writing; layout and types of research reports; technical paper writing; oral presentation of research findings; mechanics of report writing; plagiarism and research ethics. |

**Text andReference Books**

1. GargB.L.,KaradiaR.,AgarwalF.andAgarwalU.K.,AnintroductiontoResearch Methodology, RBSA Publishers, 2002
2. KothariC.R., ResearchMethodology: Methods and Techniques.NewAge International, 1990.
3. MerriamS.B.,TisdellE.J.,QualitativeResearch: A Guideto Designand Implementation, 4th edition, John Wiley & Sons, 2016.
4. CreswellJ.W., ResearchDesign: Qualitative,QuantitativeandMixedMethods Approaches, 4th edition, SAGE Publications, Inc, 2014.
5. OlsenC.,DevoreJ.,PeckR.,IntroductiontoStatisticsandDataAnalysis,5thedition, Brooks/Cole, 2015.
6. PanneerselvamR.,ResearchMethodology,2nd edition,PHILearning,2014

**Assessment: ISEI (Class Test), ISEII (TA) & ESE**

**TA: Students will perform one or more of the following activities**

1. Surprise Test
2. Assignment
3. Quiz
4. Any other activity suggested by course coordinator

**Assessment Pattern**

| **Assessment Pattern Level No.** | **Knowledge Level** | **ISE I** | **ISE II** | **End Semester Examination** |
|---|---|---|---|---|
| K1 | Remember | 05 | 02 | 06 |
| K2 | Understand | 10 | 08 | 24 |
| K3 | Apply | 00 | 03 | 09 |
| K4 | Analyze | 05 | 04 | 12 |
| K5 | Evaluate | 00 | 03 | 09 |
| K6 | Create | 00 | 00 | 00 |
| **Total** | | 10 | 10 | 30 |

| INCCC5101: Stress Management Through Yoga | | |
|---|---|---|
| **Teaching Scheme** | **Examination Scheme** | |
| **Practicals: 02 Hrs. / Week** | **Audit Course** | |
| **Credits: 0** | | |

**Course Objectives**:

This course aims at enabling students:

1. To get awareness of Physical, Mental, Social and Spiritual health
2. To learn to manage the Stress through art of Yoga.
3. Understand and perform skill of Yoga Asanas
4. Gain knowledge and benefits of Pranayam and Dhyan
5. Importance of diet, food and nutrition.

| | **Course Outcomes**<br>The students will able to - |
|---|---|
| **CO1** | Aware regarding healthy and peaceful living |
| **CO2** | Understand the cause of stress and its relief |
| **CO3** | Perform skill of Yoga Asanas and Meditation |
| **CO4** | Bring peace and harmony in the society at large |
| **CO5** | Aware of yogic diet, food and nutrition. |

**Detailed Syllabus:**

| | |
|---|---|
| **Unit1** | Introduction, meaning and definition of health, various dimensions of health, like, Physical, Mental, Social and Spiritual health |
| **Unit2** | Concept of stress according to yoga, causes and consequences of stress, stress management through Yoga. |
| **Unit3** | Introduction and definition of yoga, Fundamental concept of yoga, relationship of yoga and health. |
| **Unit4** | Yogic sukshmavyayam,Maharshi PatanjaliAshtang Yog sutra, different types and benefits of asanas ( min. five in each pose), Suryanamaskar, different types and benefits of Pranayam( min. Five), Meaning and importance of dhyan . |
| **Unit5** | Importance of yogic diet, food and nutrition. |
| **List of Practice Sessions** | 1. Practice of Yogic Sukshma Vyayam<br>2. Practice of different Asanas<br>3. Practice of different Pranayam<br>4. Practice of Dhyan |

**Text and Reference books:**


1. K, N, Udupa, Stress and its Management by Yoga, Motilal Banaridas Publishers
2. Acharya Yetendra, Yoga and Stress Management, Finger print Publications
3. B. K. S. Iyengar, Light on Yoga, Harper Collins Publisher, New Delhi, 2005
4. Swami Vivekanand, Patanjali Yog Sutra, Geeta Press, Gorakhpur
5. Swami Ramdev, Pranayam Rahasya, Divya Prakashan, 2009.

**Semester II**

| EEPCC5110: Power System Dynamics and Stability | |
|---|---|
| **Teaching Scheme** | **Examination Scheme** |
| Lectures: 3 Hrs/Week | ISE I : 20 Marks |
| Tutorial: 0 Hr/Week | ISE III : 20 Marks |
| Credits: 03 | End Sem Exam : 60 Marks |

**Course description**: This is a compulsory course & covers different stability aspects of power systems.

**Course Objectives:** The objectives of the course are to:

1. Explain the basics of power system stability.
2. Explain different methods to determine the transient stability of power systems.
3. Acquaint the students with small signal stability of power systems.
4. Introduce the concepts of voltage stability.
5. Explain the methods of stability improvement.

**Course Outcomes:** After completing the course, students will able to:

| | |
|---|---|
| CO 1 | Describe stability conditions of power systems. |
| CO 2 | Apply numerical methods to determine stability under various fault conditions. |
| CO 3 | Explain the effect of excitation on small signal stability. |
| CO 4 | Explain the concepts related to voltage stability. |
| CO 5 | Describe various methods of stability enhancement. |

**Detailed Syllabus:**

| | |
|---|---|
| **Unit 1** | **Power System stability considerations:** Definitions, classification of stability, rotor angle and voltage stability, synchronous machine representation, classical model, load modeling. Concepts modeling of excitation systems, modeling of prime movers. |
| **Unit 2** | **Transient stability:** Swing equation-equal area criterion-solution of swing equation. Numerical methods, Euler method, Runge-Kutta method, critical clearing time & angle. Effect of excitation system and governors, Multi-machine stability, extended equal area criterion, transient energy function approach. |
| **Unit 3** | **Small signal stability:** State space representation, Eigen-values, modal matrices, small signal stability of single machine infinite bus system, synchronous machine classical model representation, effect of field circuit dynamics, effect of excitation system-small signal stability of a multi machine system. |
| **Unit 4** | **Voltage stability**: Basic concepts related to voltage stability, voltage collapse, voltage stability analysis, prevention of voltage collapse |
| **Unit 5** | **Methods of improving stability:** Transient stability enhancement – high speed fault clearing – steam turbine fast valuing - high speed excitation systems- Fundamentals and performance of Power System Stabilizer – Multi band PSS – Three dimensional PSS – Location & dispatch of reactive power by VAR sources. |

**Text and Reference Books**

1. P. M. Anderson and A.A. Fouad, *Power System Control and Stability*, IOWA state university press, USA
2. P.Kunder, *Power System stability and Control*, McGraw Hill, New York
3. P. Sauer and M.A. PAI, *Power system dynamics and stability*, Prentice Hall, 1997
4. K.R.Padiyar, *Power System Dynamics, Stability and Control*, Edition II Interline Publishers, Bangalore, 1996
5. Van Cutsem, T. and Vournas, C.,*Voltage Stability of Electric Power Systems*, Kluwer Academic Publishers, 1998.
6. Taylor.C.W, *Power System Voltage Stability*, McGraw-Hill, 1994.
7. P.S.R. Murty, *Power System Operation & control*, Tata McGraw Hill
8. Allen J. Wood, and Bruce F. Wollenberg, “Power Generation, Operation and Control”, John Wiley & Sons, Inc., New York

**ISE III Assessment:** Teachers Assessment of 20 marks is based on **attendance** of the student and one of the / or combination of few of following.

1. Presentation on latest topics/Real life problems related with the subject
2. Simulations problems
3. Quiz
4. MCQ

**Sample Assessment Pattern:**

| Assessment Pattern Level No. | Knowledge Level | ISE 1 | ISE III Assignment | End Semester Examination |
|---|---|---|---|---|
| K3 | Apply | 10 | | 20 |
| K4 | Analyze | 10 | 10 | 20 |
| K5 | Evaluate | | 10 | 20 |
| **Total Marks 100** | | 20 | 20 | 60 |

**Sample Assessment table**:

| Assessment Tool | K2+K3 | K2+K3 | K2+K3 | K2+K3 | K2+K3 |
|---|---|---|---|---|---|
| | CO1 | CO2 | CO3 | CO4 | CO5 |
| ISE I Test (20 Marks) | 10 | 10 | | | |
| ISE III Assessment (20 Marks) | | | | 10 | 10 |
| ESE Assessment (60 Marks) | 12 | 12 | 12 | 12 | 12 |

**Designed by**
**Prof. M. R. Bachawad**

| **EEPCC5111: HVDC and FACTS** | |
|---|---|
| **Teaching Scheme** | **Examination Scheme** |
| Lectures: 4 Hrs/Week | ISE I : 20 Marks |
| Tutorial: 0 Hr/Week | ISE III : 20 Marks |
| Credits: 04 | End Sem Exam : 60 Marks |

**Course Objectives:**

The objectives of the course are to-

1. Understand the configuration and working of HVDC systems
2. Analyze harmonics and to understand the different protection schemes of HVDC systems
3. Understand operating principle of FACTS devices
4. Analyze the operation of shunt, series and combined compensators
5. Impart knowledge on application of shunt, series and combined compensator to improve AC transmission.

**Course Outcomes:** After completing the course, students will able to:

| | |
|---|---|
| CO1 | Review the HVDC transmission systems, design the HVDC converters |
| CO2 | Identify the suitable methods to review and reduce the harmonics in HVDC system |
| CO3 | Analyze the reactive power compensation in AC transmission systems |
| CO4 | Analyze suitable compensation for AC transmission systems |
| CO5 | Apply the concepts to electrical power transmission systems |

**Detailed Syllabus:**

| | |
|---|---|
| **UNIT-1** | **Introduction:**<br>Comparison of AC and DC transmission systems, application of DC transmission, types of DC links, layout of a HVDC converter station. HVDC converters, pulse number, analysis of Graetz circuit with and without overlap, converter bridge characteristics, equivalent circuits or rectifier and inverter configurations of twelve pulse converters |
| **UNIT-2** | **Converter & HVDC System Control:**<br>Principles of DC Link Control — Converters Control Characteristics — system control hierarchy, firing angle control, current and extinction angle control, starting and stopping of DC link. |
| **UNIT-3** | **Harmonics, Filters and Reactive Power Control:**<br>Introduction, generation of harmonics, AC and DC filters. Reactive Power Requirements in steady state, sources of reactive power, static VAR systems.<br>**Power Flow Analysis in AC/DC Systems:**<br>Modeling of DC/AC converters, Controller Equations-Solutions of AC/DC load flow, Simultaneous method-Sequential method. |
| **UNIT-4** | **Introduction to FACTS:**<br>Flow of power in AC parallel paths and meshed systems, basic types of FACTS controllers, brief description and definitions of FACTS controllers.<br>**Static Shunt Compensators:**<br>Objectives of shunt compensation, methods of controllable VAR generation, static VAR compensators, SVC and STATCOM, comparison between SVC and STATCOM. |

| | |
|---|---|
| **UNIT-5** | **Static Series Compensators**: Objectives of series compensation, variable impedance type-thruster switched series capacitors (TCSC), and switching converter type series compensators, static series synchronous compensator (SSSC)-power angle characteristics-basic operating control schemes. **Combined Compensators:** Introduction, unified power flow controller (UPFC), basic operating principle, independent real and reactive power flow controller, control structure. |

**Text and Reference Books:**

1. HVDC Transmission, S. Kamakshaiah, V. Kamaraju, The Mc-Graw Hill
2. HVDC power Transmission systems by K.R. Padiyar, Wiley Eastern Limited
3. Understanding of FACTS by N.G. Hingorani & L. Gyugyi, IEEE Press.
4. Flexible AC Transmission Systems (FACTS) Young Huasong & Alian T. hons, The Institution of Electrical Engineers, IEEE Power and Energy Series 30.

**ISE III Assessment: It is** based on one combination of following

1. Assignment
2. MCQ
3. PPT
4. Surprise Test

**Sample Assessment Pattern:**

| **Assessment Pattern Level No.** | **Knowledge Level** | **ISE 1** | **ISE III Assignment** | **End Semester Examination** |
|---|---|---|---|---|
| K3 | Apply | 10 | | 20 |
| K4 | Analyze | 10 | 10 | 20 |
| K5 | Evaluate | | 10 | 20 |
| **Total Marks 100** | | 20 | 20 | 60 |

**Sample Assessment Table:**

| Assessment Tool | K2+K3 | K2+K3 | K2+K3 | K2+K3 | K2+K3 |
|---|---|---|---|---|---|
| | CO1 | CO2 | CO3 | CO4 | CO5 |
| Class Test (20 Marks) | 10 | 10 | | | |
| Teachers Assessment (20 Marks) | | 5 | 5 | 5 | 5 |
| ESE Assessment (60 Marks) | 12 | 12 | 12 | 12 | 12 |

**Designed by Dr. S. S. Mopari**

| EEPCC5112 : Lab Power Quality & Mitigation | |
|---|---|
| **Teaching Scheme** | **Examination Scheme** |
| Practical: 02 Hrs/Week | ISE IITerm work : 25 Marks |
| Credits: 01 | Total : 25 Marks |

Term Work Shall consist of record of minimum eight experiment/assignment using engineering computation software such as MATLAB, PSCAD, ETAP with moderate to high complexity

**Part I**

Any **10** experiments from the following list

1. Familiarization with MATLAB and basics of simulation and measurement
2. Coding to write the equations, loop operations, conditional operations and draw the plots (self-study).
3. Measurement of RMS and Average value of voltage and current, calculation of power factor, and calculation of active and reactive power in Simulink, using basic blocks of MATLAB/Simulink.
4. Generation of angular positions with respect to the sensed current/voltage and measurement of frequency of the sensed signal, and power factor in Simulink simulation, for the case of a transmission line fed by an ac supply and feeding resistive/inductive/capacitive load one at a time.
5. Use of lookup table approach to calculate i. The firing angle from the required value of impedance for cases of variable impedance-based FACTs Controller. 34 ii. generate sinusoidal reference from the generated/calculated angular positions from the sensed voltage/current
6. Simulink block set for Power Electronics and Power System Components. Simulation of the basic power electronics converter topologies, such as single-phase half wave rectifier, ac voltage controller, and inverter.
7. Sizing, simulation and operation of TCSC for a transmission line fed by an ac supply and feeding resistive/inductive/capacitive load one at a time. a. Resistive/inductive/capacitive load one at a time. b. a load which can have leading as well as lagging behavior Note: all the modes of operation are required to be demonstrated
8. Sizing, simulation and operation of STATCOM for a transmission line fed by an ac supply and feeding a. Resistive/inductive/capacitive load one at a time. b. a load which can have leading as well as lagging behavior Note: Four quadrant operations is required to be demonstrated
9. Sizing, simulation and operation of SSSC for a transmission line fed by an ac supply and feeding a. Resistive/inductive/capacitive load one at a time. b. a load which can have leading as well as lagging behavior Note: Four quadrant operations is required to be demonstrated.
10. Harmonic analysis of non-linear loads using Power analyzer and its mitigation using passive filters
11. Study of ATP, PSCAD and MATLAB (Simulink)software
12. Simulation of various faults in power system
13. Simulation of AVR, PSS models
14. Study of Transient over voltages
15. Stability studies – i) Large/small signal rotor angle stability ii) voltage instability.

**Part- II**

1. Study, simulation and presentation of IEEE Transaction papers on FACTs devices related applications. (Each student has to select different paper)
2. Study, simulation and presentation of IEEE Transaction papers on Power Systems dynamics and stability related topics. (Each student has to select different paper)
3. Study, simulation and presentation of IEEE Transaction papers on topics from (Elective III, IV and V courses) related applications or topics. (Each student has to select different paper)

**Designed by Prof. B. T. Deshmukh**

| EEOEC5101 :Data Science Applications in Engineering | |
|---|---|
| **Teaching Scheme**<br>Lectures: 2 Hrs/Week<br>Tutorial: 0 Hr/Week<br>Credits: 2 | **Examination Scheme**<br>ISE I : 10 Marks<br>ISE II : 10 Marks<br>End-Semester Examination : 30 Marks<br>Total : 50Marks |

After the completion of course the students will be able to-

| | |
|---|---|
| CO1 | Distinguish between Algorithmic and Knowledge based Methods |
| CO2 | Adopt Soft Computing techniques for Engineering Problems |
| CO3 | Apply AI frame work for solving Engineering Problems |

**Detailed Syllabus**

| | |
|---|---|
| **Unit I** | **Artificial Neural Networks ANN Paradigms:**<br>ANN-Definition and Fundamental concepts -Biological Neural Network- Modeling of a Neuron, Activation functions, initialization of weights. Typical architectures, Leaning/Training laws-Supervised learning Unsupervised learning, Reinforcement learning-Perception-architectures-Linear Separability-XOR Problem - ADALINE and MADALINE |
| **Unit II** | **Deep Learning & Fuzzy Logic:**<br>Deep Architectures-Convolutional Neural Networks-Convolutional Layer-Pooling Layer- Normalization Layer- Fully Connected Layer- Deep belief Networks<br>**Fuzzy sets-** Properties, Operations and relations-Fuzzy sets-Membership functions-Basic Fuzzy set operations -Properties of Fuzzy sets-Fuzzy cartesian Product-Operations on Fuzzy relations-Fuzzy logic-Fuzzy Cardinalities-Fuzzy Logic Controller (FLC): Fuzzy Logic System Components: Fuzzification-Inference Engine-De-fuzzification methods |
| **Unit III** | **Applications of ANN and Fuzzy Logic:**<br>Load flow studies-Economic load dispatch- Load frequency control- Single area system and two area systems - Reactive power control - Speed control of DC and AC Motors. Fuzzy control applications in wide area control-ANN in hybrid state-estimation- ANN engineering applications |

**Text and Reference books**


1. Neural Networks, Fuzzy Logic & Genetic Algorithms, S. Rajasekaran and G.A.V. Pai, PHI, New Delhi, 2008
2. Fuzzy Logic with Fuzzy applications, T.J. Ross, Mc Graw Hill Inc, 1997
3. Neural Networks: A Comprehensive Foundations Simon Haykin, Pearson Edition, 2003
4. Fuzzy sets, Uncertainty and Information, G.J.Klir and T.A.Folger, PHI, Pvt.Ltd,1994
5. Neural Network & Fuzzy System, Bart Kosko, Prentice Hall, 1992


### 3. Assessment table:

| Assessment Tool | K1+K2+ K3 | K1+K2+ K3 | K1+ K2 | K2 | K1+K3 |
|---|---|---|---|---|---|
| Course outcomes | CO1 | CO2 | CO3 | CO4 | CO5 |
| ISE I Test 10 Marks | 10 | 10 | | | |
| ISE II Assessment 20 Marks | | | 10 | 10 | |
| ESE Assessment 60 Marks | 12 | 12 | 12 | 12 | 12 |

**4. Assessment Pattern:**

| Assessment Pattern Level No. | Knowledge Level | ISE I | ISE II Assignment | End Semester Examination |
|---|---|---|---|---|
| K2 | Understand | 05 | 05 | 10 |
| K3 | Apply | 05 | 05 | 10 |
| K4 | Analyze | | | 10 |
| K5 | Evaluate | | | |
| K6 | Create | | | |
| **Total** | | 10 | 10 | 30 |

**Designed By:**
**Dr. N. J. Phadkule**

| EEAEC5110: Lab Software skills | | |
|---|---|---|
| **Teaching Scheme** | **Examination Scheme** | |
| Practical: 04 Hrs/Week | ISE III | : 50 Marks |
| Tutorial : 00Hr/week | ESE | :0 Marks |
| Credits: 02 | Total | : 50 Marks |

Term work shall consist of a record of minimum eight experiments based on hardware set up/ modeling & simulation using electrical software/analysis/mini project/industrial problems/industrial visit from the following list. This set can be organized as (14–16 experiments) laboratory for M Tech Electrical Power Systems students. Here are some additional advanced and industry-oriented Software Laboratory experiments.

Suggested Software Tools

- Python
- MATLAB
- GNU Octave
- Jupyter Notebook
- Power World Simulator ,ETAP

1. **Programming for Electrical Engineering**
   **Introduction to Python/MATLAB**
   - Basic arithmetic and matrix operations.
   - Plotting electrical signals.

   **Analysis of AC Waveforms**
   - Generate sine, square, and triangular waves.
   - Calculate RMS, average, and peak values.

   **Power Factor Calculation**
   - Program to calculate real, reactive, and apparent power.
   - Determine power factor and compensation requirements.

   **Load Flow Data Handling**
   - Read bus and line data from files.
   - Create bus admittance matrix (Y-bus).
2. **Power Grid and Interconnected Power Systems**
   Formation of Y-Bus Matrix
   **Develop software for Y-bus formation using inspection method.**
   Load Flow Analysis
   **Implement Gauss-Seidel load flow algorithm.**
   Newton-Raphson Load Flow
   **Develop and compare with Gauss-Seidel results.**
   Economic Load Dispatch
   **Determine optimal generation scheduling among interconnected stations.**
   Frequency Control Simulation
   **Simulate single-area and two-area load frequency control.**
   Tie-Line Power Flow Analysis
   **Study power exchange between interconnected power stations.**
   Transmission Line Performance
   **Calculate voltage regulation and efficiency.**
   Power System Fault Analysis
   **Symmetrical fault current calculation using software.**

3. **Smart Meter Data Analysis**

Read and visualize smart meter datasets.

**Load Forecasting**

Short-term electrical load prediction using historical data.

**Demand Response Analysis**

Study consumer load shifting and peak reduction.

**Renewable Energy Integration**

Analyze solar/wind generation variability.

**4Data Science Applications in Electrical Engineering**

Electrical Data Visualization

**Plot voltage, current, frequency, and power trends.**

Power Consumption Pattern Analysis

**Statistical analysis of energy consumption data.**

Transformer Condition Monitoring

**Analyze temperature and loading datasets.**

Anomaly Detection in Power Systems

**Detect abnormal voltage or current measurements.**

Machine Learning for Load Prediction

**Apply linear regression for demand forecasting.**

Fault Classification Using Machine Learning

**Classify fault types from simulated data.**

Power Quality Analysis

**Identify voltage sags, swells, and harmonics from datasets.**

Mini Project

**Develop a complete software solution for a grid, substation, or smart energy system using programming and data analytics.**

Grid and Power System Applications

**DC Load Flow Analysis**

Develop a program for DC load flow and compare with AC load flow results.

**Contingency Analysis**

Study the effect of line or generator outages on system performance.

**Optimal Power Flow (OPF)**

Minimize generation cost while satisfying system constraints.

**State Estimation in Power Systems**

Estimate bus voltages using measured data.

**Voltage Stability Analysis**

Determine voltage stability margins under increasing load conditions.

**Unit Commitment Problem**

Schedule generating units for minimum operating cost.

**Relay Coordination Study**

Simulate overcurrent relay settings and coordination.

**Transmission Network Expansion Planning**

Analyze the need for additional transmission lines.

**Renewable Energy and Smart Grid**

Solar PV Performance Analysis

**Analyze solar irradiation and power output datasets.**

Wind Power Forecasting

**Predict wind generation using historical data.**

Battery Energy Storage Management

**Develop algorithms for charging/discharging optimization.**
Microgrid Energy Management
**Optimize operation of distributed energy resources.**
Electric Vehicle Charging Load Analysis
**Study impact of EV charging on distribution networks.**
Virtual Power Plant Simulation
**Aggregate renewable sources and storage for grid support.**

1. **Data Science and Artificial Intelligence Applications**

Time Series Analysis of Load Data
**Use moving averages and trend analysis.**
Energy Consumption Clustering
**Group consumers based on usage patterns.**
Predictive Maintenance of Transformers
**Analyze condition monitoring data for failure prediction.**
Machine Learning-Based Fault Detection
**Train models using fault datasets.**
Classification of Power Quality Disturbances
**Identify harmonics, sags, swells, and interruptions.**
Electricity Price Forecasting
**Predict market prices using historical data.**
Energy Theft Detection
**Detect abnormal consumption patterns using analytics.**
Neural Network-Based Load Forecasting
**Compare results with conventional forecasting methods.**

2. **Signal Processing Applications**

FFT Analysis of Electrical Signals
**Determine harmonic content in waveforms.**
Digital Filter Design
**Design low-pass, high-pass, and band-pass filters.**
Power Quality Monitoring System
**Develop software for monitoring voltage and current quality.**
Wavelet-Based Disturbance Detection
**Detect transient events in power systems.**

3. **Visualization and Digital Twin Applications**

SCADA Data Visualization Dashboard
**Create real-time monitoring dashboards.**
Substation Monitoring System
**Develop graphical interfaces for equipment monitoring.**
Digital Twin of a Distribution Feeder
**Simulate feeder behavior under varying load conditions.**
Geographical Information System (GIS) for Power Networks
**Visualize transmission and distribution networks on maps.**
PMU (Phasor Measurement Unit) Data Analysis
**Analyze synchrophasor measurements for grid monitoring.**

**Term Work:**

The term work shall consist of performance of above enlisted experiments and submission of technical write up. The term work will be assessed by the Course Coordinator.

**Practical Examination:**

The practical examination will consist of performance of experiment and viva-voce or viva voce on the complete curriculum of the lab course. The internal and external examiners appointed by the Controller of Examination will assess the performance of the student.

| EEPEC5112: Machine Learning and Applications | | | |
|---|---|---|---|
| **Teaching Scheme** | | **Examination Scheme** | |
| Lectures | : 03 Hrs/Week | ISE | : 20 Marks |
| Tutorial | : 00 | ISE III | : 20 Marks |
| Total Credits | : 03 | End -Semester Exam | : 60 Marks |

Course Outcomes (COs):

At the end of the course, the student will be able to

| | |
|---|---|
| **CO1** | Understand basic concepts of Machine Learning Techniques |
| **CO2** | Distinguish between supervised learning, unsupervised learning and reinforced learning |
| **CO3** | Develop the skills in using machine learning software for solving practical problems |
| **CO4** | Apply Machine Learning Algorithms for Electrical Engineering problems |

**Detailed syllabus:**

| | |
|---|---|
| **Unit I** | **Neural Networks:** Introduction to Neural Networks, Models of Neuron Network, Architectures, Knowledge representation, Artificial Intelligence and Neural Networks, Learning Process, Error Correction Learning, Multi-layer perceptron using Back Propagation Algorithm (BPA) Learning Theory**:** Introduction to Machine Learning, Learning Objectives, Data needed, Bayesian inference and Learning, Bayes theorem, inference - naïve Bayes, Regularization, Bias-Variance Decomposition and Trade-off, Concentration Inequalities, Generalization and Uniform Convergence, VC dimension. Types of Learning, Supervised Learning, Unsupervised Learning and Reinforcement Learning |
| **Unit II** | **Supervised Learning:** Simple linear Regression, Multiple Linear Regression- Logistic Regression, Exponential Family and Generalized Linear Models- Generative Models: Gaussian Discriminant Analysis, Naïve Bayes Kernel Method: Support Vector Machine (SVM), Kernel function, Kernel SVM, Gaussian Process Tree Ensembles: Decision Trees- Random Forests, Boosting and Gradient Boosting |
| **Unit III** | **Un-Supervised Learning: (CLUSTERING):** K-means Clustering Algorithm, Gaussian Mixture Model (GMM), Expectation Maximization (EM), Variational Auto Encoder (VAE) Factor Analysis, Principle Components Analysis (PCA) Independent Component Analysis (ICA |
| **Unit IV** | **Reinforcement Learning:** Markov Decision Processes (MDP)-Bellman’s Equations, Value Iteration and Policy Iteration Value Function Approximation Q Learning |
| **Unit V** | **Applications of ML:** Load Forecasting, Energy Market forecasting, Fault identification and localization, Renewable Uncertainty estimation |

**Text and Reference Books:**


1. Pattern Recognition and Machine Learning, Christopher Bishop, Springer, 2011
2. Machine Learning, E. Alpaydin, MIT Press, 2010 Reference Books:
3. Machine Learning, Tom M. Mitchell, McGraw Hill International Edition, 1997
4. Online Resources: https://www.learndatasci.com/best-machine-learning-courses/


**ISE III Assessment:** Teachers Assessment of 20 marks is based on one or combination of few of following. However, the course co-ordinator has to announce assessment components at the beginning of the course.

1. Presentation on latest topics/Real life problems related with the subject
2. Problems based on GATE questions
3. Simulations problems
4. Quiz

**Sample Assessment Pattern:**

| **Assessment Pattern Level No.** | **Knowledge Level** | **Test** | **ISE III Assessment** | **End Semester Examination** |
|---|---|---|---|---|
| K2 | Understand | 10 | 10 | 20 |
| K3 | Apply | 10 | 10 | 20 |
| K4 | Analyze | | | 20 |
| K5 | Evaluate | | | |
| K6 | Create | | | |
| **Total Marks 100** | | 20 | 20 | 60 |

**Sample Assessment table**:

| Assessment Tool | K2+ K3 | K2+ K3 | K2+ K3 | K2+ K3 | K2+K3 |
|---|---|---|---|---|---|
| | CO1 | CO2 | CO3 | CO4 | CO5 |
| ISE I Test (20 Marks) | 10 | 5 | 5 | | |
| ISE III Assessment (20 Marks) | | | | 10 | 10 |
| ESE Assessment (60 Marks) | 10 | 20 | 10 | 10 | 10 |

**Designed by Dr. N. J. Phadkule**

| EEPEC5113 : Optimization Techniques | |
|---|---|
| **Teaching Scheme**<br>Lectures: 03 Hrs/Week<br>Tutorial : 0 Hrs/Week<br>Credits : 3 | **Examination Scheme**<br>ISE I : 20 Marks<br>ISE III : 20 Marks<br>End Semester Exam : 60 Marks |

**Course Description**: Electrical Power Systems is growing at a faster pace. An Electrical Engineer should be able to solve the optimization problems in electrical engineering. This course is aimed to cover the fundamentals of LPP and NLPP optimization techniques for solving engineering problems.

**Course Objectives:** The objectives of the course are to
1. Introduce the fundamental concepts of Optimization Techniques;
2. Make the learners aware of the importance of optimizations in real scenarios;
3. Provide the concepts of various classical and modern methods for constrained and unconstrained problems in both single and multivariable.

**Course Outcomes :** After completing the course, students will able to:

| | |
|---|---|
| CO1 | formulate optimization problems |
| CO2 | understand and apply the concept of optimality criteria for various type of optimization problems |
| CO3 | solve various constrained and unconstrained problems in single variable as well as multivariable; |
| CO4 | apply the methods of optimization genetic algorithm for real life situation |
| CO5 | apply the methods of optimization techniques for the application in power system engineering |

**Detailed Syllabus:**

| | |
|---|---|
| **Unit 1** | **Introduction:**<br>Concept of optimization and classification of optimization techniques, formation of optimization problems<br>Linear Programming : Standard form of LPP Simplex Method of solving LPP, duality in LP, transportation problem |
| **Unit 2** | **Non-Linear Problem (NLP) :**<br>One dimensional methods: Elimination methods, Interpolation methods,<br>Unconstrained optimization techniques:-Direct search and gradient based methods, Constrained optimization techniques:-lagrange multiplier method, Kuhn-Tucker Conditions, Cutting plane Method, penalty function Methods |
| **Unit 3** | **Dynamic Programming:**<br>Multistage decision processes, concept of sub-optimization and principle of optimality, conversion of final value problem into an initial value problem. |
| **Unit 4** | **Advanced Optimization Techniques:**<br>Introduction to Multi objective Optimization, Swarm intelligences, Genetic Algorithm, Teaching Learning Based Optimization, and other Non-traditional Optimization Algorithms, applications. |
| **Unit 5** | **Applications to Power system:**<br>Economic Load Dispatch in thermal and Hydro-thermal system Unit commitment problem, reactive power optimization. Optimal power flow, LPP and NLP techniques to Optimal flow problems. |

**Text and Reference Books**

**Text book :**

1. S.S.Rao, "Optimization - Theory and Applications", Wiley-Eastern Limited.
1. David G. Luenberger, "Introduction of Linear and Non-Linear Programming ", Wesley Publishing Company
2. Polak, "Computational methods in Optimization", Academic Press. Pierre D.A, "Optimization Theory with Applications", Wiley Publications.
4.Kalyanmoy deb, "Optimization for Engineering Design: Algorithms and Examples", Kalyanmoy deb, PHI Publication.
5.D.E. Goldberg & Addision, "Genetic Algorithm in Search Optimization and Machine Learning ", Wesley Publication, 1989
6.L.P. Singh, "Advanced Power System Analysis and Dynamics", Wiley Eastern Limited.
7.Hadi Saadat "Power System Analysis ", TMH Publication.

**ISE III Assessment:** Teachers Assessment of 20 marks is based on **attendance** of the student and one of the / or combination of few of following. However, the course co-ordinator has to announce assessment components at the beginning of the course.

5. Presentation on latest topics/Real life problems related with the subject
6. Problems based on GATE questions
7. Simulations problems
8. Quiz

**Sample Assessment Pattern:**

| **Assessment Pattern Level No.** | **Knowledge Level** | **Test** | **ISE III Assessment** | **End Semester Examination** |
|---|---|---|---|---|
| K2 | Understand | 10 | 10 | 20 |
| K3 | Apply | 10 | 10 | 20 |
| K4 | Analyze | | | 20 |
| K5 | Evaluate | | | |
| K6 | Create | | | |
| **Total Marks 100** | | 20 | 20 | 60 |

**Sample Assessment table**:

| Assessment Tool | K2+ K3 | K2+ K3 | K2+ K3 | K2+ K3 | K2+K3 |
|---|---|---|---|---|---|
| | CO1 | CO2 | CO3 | CO4 | CO5 |
| ISE I Test (20 Marks) | 10 | 5 | 5 | | |
| ISE III Assessment (20 Marks) | | | | 10 | 10 |
| ESE Assessment (60 Marks) | 10 | 20 | 10 | 10 | 10 |

**Designed by Dr. S. P. Ghanegaonkar**

| PEC5114: Power Quality and Mitigation | | | |
|---|---|---|---|
| **Teaching Scheme** | | **Examination Scheme** | |
| Lectures | : 03 Hrs/Week | ISE I | : 20 Marks |
| Tutorial | : 00 | ISE III | : 20 Marks |
| Total Credits | : 03 | End -Semester Exam | : 60 Marks |

**Pre-requisites:** Power Electronics, Electrical Machines, Power System
**Course Description:**

This course gives an introduction on power quality causes and effects, requirement of power quality improvements and mitigation aspects of power quality problems.
**Course Objectives:** The objectives of the course are to
1. Understand power quality problem and classify power quality events
2. Understand different methods of monitoring power quality and standards for power quality
3. Outline concept of Passive shunt and series compensators
4. Understand Active Shunt And Series Compensators
5. Understand Unified Power Quality Compensators

**Course Outcomes:** After completing the course, students will able to

| | |
|---|---|
| **CO1.** | Identify and describe Power quality problems and classify power quality events. |
| **CO2** | Evaluate power quality indices in distribution system |
| **CO3** | Develop mitigation techniques for compensating devices to improve power quality in distribution systems |
| **CO4** | Suggest compensating devices to improve power quality in distribution system |
| **CO5** | Analyze Unified Power Quality Compensators |

**Detailed syllabus:**

| | |
|---|---|
| **Unit-I** | **Power Quality:**<br>Significance of power quality, Power quality terms: Transients, Long-duration voltage variations, Short-duration voltage variations, Voltage imbalance, Waveform distortion, Voltage fluctuation, CBEMA and ITI curves. Devices for Overvoltage Protection: Surge arresters and transient voltage surge suppressors, Isolation transformers and Low-impedance power conditioners.<br>**Waveform Distortion:** Introduction, Voltage versus current distortion, Harmonics versus transients, Harmonics indices: Total Harmonics Distortion (THD) and Total Demand distortion (TDD); Harmonic standards; Harmonic analysis; Harmonic phase sequence; Triplen harmonics; Inter harmonics. |
| **Unit-II** | **Harmonic Sources:**<br>Harmonics generated from electrical machines such as transformers and rotating machines; Arcing devices; Static power conversion: Phase controlled and uncontrolled rectifiers, AC voltage regulators, Cycloconverters, Pulse width modulated inverters; Converter fed ac and dc drives |

| | |
|---|---|
| **Unit-III** | **Effects of Harmonic Distortion:**<br>Resonances; Effects of harmonics on rotating machines; Effect of harmonics on static power plant; Power assessment with distorted waveforms; Effect of harmonics on measuring instruments; Harmonic interference with ripple control systems; Harmonic interference with power system protection; Effect of harmonics on consumer equipment; Interference with communication systems |
| **Unit-IV** | **Harmonic Elimination:**<br>Passive power filters: Design, A Shunt active power filters: Configurations, State of the art, Design and control strategies. Three-phase four-wire shunt active power filters |
| **Unit-V** | **Voltage Quality:**<br>Sources of Sags, Swell, Unbalance and Flicker; Voltage quality standards; Effects of sags, Swell, Unbalance and Flicker; Voltage sag magnitude due to fault; Voltage sag magnitude calculation based on influence of cross section of conductor, transformer and fault levels; Critical distance for a voltage sag magnitude; Causes of phase- angle jumps in voltage; Classification of voltage sags, voltage sag transformation due to transformers. |

**ISE III Assessment:** Teachers Assessment of 20 marks is based on **attendance** of the student and one of the / or combination of few of following. However, the course co-ordinator has to announce assessment components at the beginning of the course.

1. Presentation on latest topics/Real life problems related with the subject
2. Problems based on GATE questions
3. Simulations problems
4. Quiz

**Sample Assessment Pattern:**

| **Assessment Pattern Level No.** | **Knowledge Level** | **ISE I** | **ISE III Assessment** | **End Semester Examination** |
|---|---|---|---|---|
| K3 | Apply | 10 | 10 | 20 |
| K4 | Analyze | 10 | 10 | 20 |
| K5 | Evaluate | | | 20 |
| K6 | Create | | | |
| **Total Marks 100** | | 20 | 20 | 60 |

**Sample Assessment table**:

| Assessment Tool | K2+ K3 | K2+ K3 | K2+ K3 | K2+ K3 | K2+K3 |
|---|---|---|---|---|---|
| | CO1 | CO2 | CO3 | CO4 | CO5 |
| ISE I Test (20 Marks) | 10 | 5 | 5 | | |
| ISE III Assessment (20 Marks) | | | | 10 | 10 |
| ESE Assessment (60 Marks) | 10 | 20 | 10 | 10 | 10 |



Dr. N. R. Bhasme
Head, Electrical

Dr. Anil Karwankar
Dean , Academics

**Designed by**
**Prof. B. T. Deshmukh**

| **EEPEC6110: Reliability and Condition Monitoring** | | | |
|---|---|---|---|
| **Teaching Scheme** | | **Examination Scheme** | |
| Lectures | : 03 Hrs/Week | ISE I | : 20 Marks |
| Tutorial | : 0 Hr/Week | ISE III | : 20 Marks |
| Total Credits | : 03 | End -Semester Exam | : 60 Marks |

**Course Objective:**
The objectives of the course are to
1. Know engineering system monitoring and fault diagnosis and explains the basic concepts of condition monitoring.
2. Know how modern technology, quality control and environmental issues have affected current thinking.
3. Protect themselves and others in the workplace and focus on the safety measures needed when Carrying out monitoring activities, especially those for isolating equipment.
4. Know how to use a range of condition monitoring equipment and will develop the skills and knowledge required for the location and identification of faults in engineering systems.
5. Learners will be required to select the appropriate monitoring technique and equipment based on the type of plant or equipment being monitored and the conditions checked.

**Course Outcomes:** After completing the course, students will be able to:

| | |
|---|---|
| CO1 | Know the health and safety requirements relevant to monitoring and fault diagnosis of engineering Systems. |
| CO2 | Know about system monitoring and reliability. |
| CO3 | Use monitoring and test equipment |
| CO4 | Carry out fault diagnosis on electrical engineering equipment |
| CO5 | Develop model for improvement in life of electrical equipment. |

**Detailed Syllabus:**

| | |
|---|---|
| **Unit 1** | **Introduction to the field of machine condition monitoring:**<br>methods, tools used to monitor a machine, diagnostics and prognostics, reliability, maintenance practices, health usage monitoring, Frequency of monitoring, infrared thermography, Ultrasounds |
| **Unit 2** | **Failure analysis:**<br>Failure mode-effect and criticality analysis, fault tree analysis. Breakdown mechanisms in gasses, liquids, vacuum, solids. maintenance strategies (breakdown, preventive, planned, scheduled, diagnostic, total productive maintenance, reliability centered maintenance) organization for maintenance, maintenance requirements, maintenance planning and work control, maintenance records, frequency of maintenance, cost of maintenance, maintenance effectiveness |
| **Unit 3** | **Condition Monitoring of Transformer:**<br>Type of faults, duration and the impacts Interpretation of gasses generated in Oil-Immersed Transformer, Transformer winding and core deformation detection utilizing SFRA technique, Methods of Dissolved Gas Analysis (DGA), partial discharge |

| | |
|---|---|
| **Unit 4** | **Diagnosis of electrical equipment:**<br>Motors, generators, Configuration, problems, diagnosis and solutions, Causes of motor failure, remedies. Signature analysis, condition monitoring of induction motor, power cables |
| **Unit 5** | **Substation Maintenance:**<br>Types – Routine, Preventive, Planned, Predictive, Break-down, Emergency maintenance, on-line maintenance of different equipments, Condition monitoring of power apparatus, New advanced techniques in diagnosis and monitoring of electrical equipment. |

**Text and Reference Books:**


1. Advances in high voltage engineering, edited by A. Haddad and D. Warne, IEEE Power and Energy Series, 2004.
2. Electrical Insulation in Power Systems, N. H. Malik, A. A. Al-Arainy and M. I. Qureshi, Marcel Dekker,1997.
3. Insulation of High Voltage Equipment, V.Y. Ushakov, Springer-Verlag, 2004.
4. High Voltage Engineering Fundamentals, KuffelZaengelKuffel, Newnes
5. K. B. Raina, S. K. Bhattacharya, Electrical Design, Estimation and costing, wiley eastern limited NewDelhi 1991.
6. S. L. Uppal- Electrical Power- Khanna Publishers Delhi.
7. Condition Monitoring and Assessment of Power Transformers Using Computational Intelligence, W.H. Tang, Q.H. Wu ,ISBN: 978-0-85729-051-9
8. Handbook of Condition Monitoring: Techniques and Methodology Edited by A. Davies
9. Advances in Electrical Engineering and Electrical Machines Editors: DehuaiZheng, ISBN: 978-3- 642-25904-3


**ISE III Assessment:** Teachers Assessment of 20 marks is based on attendance of the student and one of the / or combination of few of following. However, the course coordinator has to announce assessment components at the beginning of the course.

1. Presentation on latest topics/Real life problems related with the subject
2. Problems based on GATE questions
3. Simulations problems
4. Quiz

**Sample Assessment Pattern:**

| | Knowledge Level | ISE I | ISE III Assessment | End Semester Examination |
|---|---|---|---|---|
| K2 | Understand | 05 | | 20 |
| K3 | Apply | 10 | 10 | 20 |
| K4 | Analyze | 05 | 10 | 20 |
| K5 | Evaluate | | | |
| K6 | Create | | | |
| **Total Marks 100** | | 20 | 20 | 60 |

**Sample Assessment Table:**

| Assessment Tool | K2+K3 | K2+K3 | K2+K3 | K2+k3 | K2+K3 | K2+ K3 | K2+ K3 |
|---|---|---|---|---|---|---|---|
| | C01 | C02 | C03 | CO4 | CO5 | CO6 | CO7 |
| ISE I Test (20 Marks) | 10 | 05 | 05 | | | | |
| Teachers Assessment (20 Marks) | 4 | 4 | 4 | 4 | 4 | | |
| ESE Assessment (60 Marks) | 12 | 12 | 06 | 06 | 06 | 06 | 12 |

**Designed by**
**Dr. N. J. Phadkule**

| EEPCC6111: Advanced Control System | |
|---|---|
| **Teaching Scheme** | **Examination Scheme** |
| Lectures: 03 Hrs/Week | ISE I : 20 Marks |
| Tutorial: 0Hrs/Week | ISE III : 20 Marks |
| Credits: 03 | End Semester Exam : 60 Marks |

**Course Description:**
The course introduce the various state feedback, nonlinear and digital control systems which will be helpful for understanding its applications in power systems and electrical drives,.

**Course Objectives:**
The objectives of the course are to-
1. Explain the system representation in state space and design of state feedback
2. Explain the basics for design of robust control system
3. Explain the stability analysis of nonlinear control systems
4. Explain the representation of optimal control systems
5. Explain the applications industrial controllers
6. Explain the multi-loop control systems

**Course Outcomes:** After completing the course, students will able to:

| | |
|---|---|
| CO1 | Explain systems in state space model |
| CO2 | Design control system state feedback |
| CO3 | Analyze the stability of nonlinear control systems |
| CO4 | Formulate and represent the systems in standard form of optimal control |
| CO5 | Apply industrial control for system and realize multi-loop control system |

**Detailed Syllabus**

| | |
|---|---|
| **Unit-1** | **Compensator design in frequency domain:**<br>Compensator design in frequency domain to improve steady state and transient response. Feedback and Feed forward compensator design using bode diagram. Lead, Lag and Lead Lag compensator design. |
| **Unit-2** | **State feedback control system:**<br>Concepts of state, state variable, state model, state models for linear continuous time functions & physical systems. Diagonalization of transfer function, solution of state equations, concept of controllability & observability effect of pole zero cancellation, pole placement design through state feedback. Ackerman's Formula for feedback gain design. Design of Observer. Reduced order observer. Separation Principle. |
| **Unit-3** | **Control Design:**<br>Design of PI/PID controller Design of P, PI, PD and PID controllers in time domain and frequency domain for first, second and third order systems. Control loop with auxiliary feedback- Feed forward control. Introduction to process control, various control configurations such as: feed-forward, cascaded etc. PID controller and implementation<br>Digital Control System: Discrete time systems, discretization, sampling, aliasing, choice of sampling frequency, ZOH equivalent, Jury's stability criteria, Bilinear transfornation |

| | |
|---|---|
| **Unit-4** | **Nonlinear Control system:**<br>Introduction to nonlinear systems, phase plane and describing function methods for analysis of linear systems and linearization using Describing function analysis, phase plane analysis, bang-bang control system, Lyapunovs stability analysis |
| **Unit-5** | **Optimal Control System:**<br>Introduction to optimal control system, problems, Quadratic performance index, Formulation of optimal control problem, linear quadratic regulator (LQR), Introduction to Adaptive control |

**Text and reference books:**


1. S. Sastry and M. Bodson, "Adaptive Control: Stability, Convergence, and Robustness", Prentice-Hall, 1989.
2. Gopal. M., "Control Systems: Principles and Design", Tata McGraw-Hill, 1997.
3. Kuo, B.C., "Automatic Control System", Prentice Hall, sixth edition, 1993.
4. Ogata, K., "Modern Control Engineering", Prentice Hall, second edition, 1991.
5. Nagrath Gopal, "Modern Control Engineering", New Age International


**ISE III Assessments:**

Assessments will be based on following:

1. Assignment 10Marks
2. MCQ 10 Marks

**Sample Assessment Pattern:**

| **Assessment Tool** | **K2+K3** | **K2+K3** | **K2+K3** | **K2+K3** | **K2+K3+K4** |
|---|---|---|---|---|---|
| | C01 | C02 | C03 | CO4 | CO5 |
| ISE I Test<br>(20 Marks) | 10 | 10 | - | - | - |
| ISE III Assessment<br>(20 Marks) | 0 | 0 | 0 | 10 | 10 |
| ESE Assessment<br>(60 Marks) | 12 | 12 | 12 | 12 | 12 |

**4. Assessment Pattern:**

| **Assessment Pattern Level No.** | **Knowledge Level** | **ISE 1** | **ISE III Assignment** | **End Semester Examination** |
|---|---|---|---|---|
| K3 | Apply | 10 | | 20 |
| K4 | Analyze | 10 | 10 | 20 |
| K5 | Evaluate | | 10 | 20 |
| **Total Marks 100** | | 20 | 20 | 60 |

**Designed by Dr. S. S. Kulkarni**

| EEPCC 6112 Control of Electrical Drives | | | |
|---|---|---|---|
| **Teaching Scheme** | | **Examination Scheme** | |
| Lectures | : 3 Hrs/Week | ISE I | : 20 Marks |
| Tutorial | : 0 Hr/Week | ISE III | : 20 Marks |
| Total Credits | : 4 | End -Semester Exam | : 60 Marks |

**Course Description**: The objective of this course is to give exposure to the students of fundamentals, operations, control and analysis of DC motor and AC motor electrical drives. It also covers the industrial application of it.

**Course Objective:**

The objective of this course is to give exposure to the students of

1. Fundamentals of an electrical drives
2. Basics, Control and analysis of DC motor drives
3. Basics, Control and analysis of Induction motor drives
4. Vector control of Induction motor drives
5. Basics, Control and analysis of PM Synchronous and Brushless DC motor drives

**Course Outcomes**

After completing the course, students will able to:

| | |
|---|---|
| CO1 | Describe fundamentals of an electrical drives |
| CO2 | Explain the operations and analysis of Phase controlled and Chopper controlled DC Motor drives |
| CO3 | Explain the operations and analysis of Phase controlled and Frequency Controlled Induction Motor Drives |
| CO4 | Discuss the principle and analysis of Vector controlled Induction Motor Drives |
| CO5 | Discuss the principle of operation, analysis of P.M. Synchronous and Brushless DC Motor Drives |

**Detailed Syllabus:**

| | |
|---|---|
| **Unit 1** | **Phase Controlled and Chopper Controlled DC Motor Drives:**<br>Phase Controlled- Introduction, Principle of DC motor speed control, Phase controlled converters, Steady state analysis of three phase converter controlled DC Motor drives, Applications.<br>Chopper Controlled- Introduction, Principle of the chopper, Four quadrant Chopper circuit, Chopper for inversion, Steady state analysis of chopper controlled DC motor drives, Applications. |
| **Unit 2** | **Voltage Fed and Current Fed Converters:**<br>Voltage Fed Converters- Introduction, Single phase inverters, Three phase bridge inverters, multi stepped inverters, PWM techniques, Three level inverters, hard switching effects, resonant inverters, soft- switched inverters, dynamic and regenerative drive braking, PWM rectifiers, Static VAR compensators.<br>Current Fed Converters- Introduction, General operation of six stepped thyristor inverter, Load commutated inverters, Force commutated inverters, harmonic heating and torque pulsation, multi stepped inverters, inverter with self commutated devices. |

| | |
|---|---|
| **Unit 3** | **Induction Motor Slip-Power Recovery Drives:** Introduction, Doubly fed machine speed control by rotor rheostat, static Kramer drives, Static Scherbius drive, modified static Scherbius drive. Principle of vector control of IM, Indirect vector control with feedback, Indirect vector control with feed-forward, Indirect vector control in various frames of reference, Decoupling of vector control with feed forward compensation, Direct Torque Control of IM, control of wound rotor induction machine, introduction to five-phase induction motor drives |
| **Unit 4** | **Control and Estimation of Induction Motor Drives**: Introduction, Induction Motor control with small signal model, Scalar Control, Vector or Field oriented control, Sensorless vector control, direct torque and flux control, Adaptive control, Self commissioning drive. |
| **Unit 5** | **Control and Estimation of Synchronous Motor Drives:** Permanent Magnet Drives: Expression for torque, Model of PMSM, Implementation of vector control for PMSM, BLDC drives Switched Reluctance Motor Drives: Torque expression, converters for SRM drives, Sinusoidal SPM machine drives, Synchronous reluctance machine drive, sinusoidal IPM machine drive, trapezoidal SPM machine drive, Wound Field synchronous machine drive, switched reluctance motor drives. |

**Textbooks/References:**


1. B. K. Bose, “Modern Power Electronics and AC drives”, Pearson Education, Asia, 2003
2. R. Krishan, “Electric Motor Drives-Modeling Analysis and Control”, Pearson Prentice Hall.
3. G.K. Dubey, “Fundamentals of Electrical Drives”, Narosa Publication
4. N.K. De and P.K.Sen “Electric Drives”, Prentice Hall India
5. B.K. Bose, “Power Electronics and Variable Frequency Drive”, IEEE Press, 2000
6. VedamSubramanyam, “Electric Drives Concepts and Applications”, Tata McGraw-Hill


**ISE III Assessments:**

Assessments will be based on any one or two of the following:

4. Assignment 10 Marks
5. MCQ 10Marks
6. PPT 10Marks
7. Surprise Test 10Marks

**Sample Assessment Pattern:**

| **Assessment Tool** | **K2+K3** | **K2+K3** | **K2+K3** | **K2+K3** | **K2+K3+K4** |
|---|---|---|---|---|---|
| | C01 | C02 | C03 | CO4 | CO5 |
| ISE I Test (20 Marks) | 10 | 10 | - | - | - |
| ISE III Assessment (20 Marks) | 0 | 0 | 0 | 10 | 10 |
| ESE Assessment (60 Marks) | 12 | 12 | 12 | 12 | 12 |

## 4. Assessment Pattern:

| Assessment Pattern Level No. | Knowledge Level | ISE 1 | ISE III Assignment | End Semester Examination |
|---|---|---|---|---|
| K3 | Apply | 10 | | 20 |
| K4 | Analyze | 10 | 10 | 20 |
| K5 | Evaluate | | 10 | 20 |
| **Total Marks 100** | | 20 | 20 | 60 |

**Designed by Dr. N.R. Bhasme**



Dr. N. R. Bhasme
Head, Electrical

Dr. Anil Karwankar
Dean , Academics

| EEPEC6113 : Energy Storage Systems | | | |
|---|---|---|---|
| **Teaching Scheme** | | **Examination Scheme** | |
| Lectures | : 03 Hrs/Week | ISE I | : 20 Marks |
| Tutorial | : 00 | ISE III | : 20 Marks |
| Total Credits | : 3 | End-Semester Exam | : 60 Marks |

**Course Description:** Coverage of energy storage techniques involving electrochemical, mechanical and emerging options. Integration of the energy storage media, its effects on the bulk power system, and design tradeoffs to understand environmental impacts, cost, reliabilities, and efficiencies for commercialization of bulk energy storage.

**Course Objectives:** The objectives of the course are to
1. Understand energy storage needs
2. Study and compare different methods of Electro-chemical energy storages
3. Understand superconducting magnetic energy storage systems
4. Get knowledge of mechanical and thermal energy storage systems
5. Study various energy storage applications and management of storage systems

**Course Outcomes:** After completing the course, students will able to

| | |
|---|---|
| **CO1.** | Describe the need of energy storage systems - present and future |
| **CO2** | Demonstrate working/ operational principles of various Electrochemical Energy Storage systems |
| **CO3** | Explain superconducting magnetic energy storage systems |
| **CO4** | Explain mechanical energy storage and Thermal energy storage systems |
| **CO5** | Select appropriate energy storage systems for various applications and demonstrate management of energy storage systems |

**Detailed Syllabus:**

| | |
|---|---|
| **UNIT-I** | **Necessity of Energy Storage:** Storage Needs - Variations in Energy Demand - Variations in Energy Supply - Interruptions in Energy Supply - Transmission Congestion - Demand for Portable Energy - Demand and scale requirements - Environmental and sustainability issues, future prospect of storage |
| **UNIT-II** | **Electrochemical Energy Storage:** Electrochemical storage system (11 Hours) (a) Batteries-Working principle of battery, primary and secondary (flow) batteries, battery performance evaluation methods, major battery chemistries and their voltages- Li-ion battery & Metal hydride battery vs lead-acid battery. (b) Super-capacitors- Working principle of super-capacitor, types of super-capacitors, cycling and performance characteristics, difference between battery and super-capacitors, Introduction to Hybrid electrochemical super-capacitors (c) Fuel cell: Operational principle of a fuel cell, types of fuel cells, hybrid fuel cell-battery systems, hybrid fuel cell-super-capacitor systems |

| | |
|---|---|
| **UNIT-III** | **Superconducting Magnetic Energy Storage:** Introduction to Superconducting Magnetic Energy Storage (SMES) operation, theory of usage and emergent research. Focus will primarily be on large utility scale energy storage facilities |
| **UNIT-IV** | **Mechanical Energy Storage and Thermal Energy Storage:** Flywheel, Pumped hydro storage, compressed gas storage technologies, models for compressed gas capacity, efficiency and availability<br>Thermal Energy Storage- Phase Change Materials (PCMs); Selection criteria of PCMs; Stefan problem; Solar thermal LHTES systems; Energy conservation through LHTES systems; LHTES systems in refrigeration and air-conditioning systems |
| **UNIT-V** | **Applications:** Present status of applications, Utility use (Conventional power generation, Grid operation & Service), Consumer use (Uninterruptible power supply for large consumers), New trends in application, Renewable energy generation, Smart grid, Electric vehicles, Management and control hierarchy of storage systems, Internal configuration of battery storage systems, External connection of EES systems |

**Text and Reference Books:**

1. Ter-Gazarian, A.G. (2011) *Energy Storage for Power Systems, 2nd Edition*, IET Publications (ISBN: 978-1849192194)
2. Huggins, R.A. (2010) *Energy Storage*, Springer, (ISBN: ISBN 978-1441910240)
3. R. P. Deshpande, "Ultracapacitors", McGraw Hill Education Publication.
4. Robert A. Huggins, "Energy Storage", Springer Publication.
5. Fransisco Diaz," Energy storage in power systems", published by Wiley.

**Sample Assessment Table:**

| Assessment Tool | K2+K3 | K2+K3 | K2+K3 | K2+K3 | K2+K3 |
|---|---|---|---|---|---|
| Course outcomes | CO1 | CO2 | CO3 | CO4 | CO5 |
| ISE I 20 Marks | 10 | 10 | | | |
| ISE III Assessment 20 Marks | | | 10 | 10 | |
| ESE Assessment 60 Marks | 12 | 12 | 12 | 12 | 12 |

**ISE III Assessment:** It is based on one or combination of the following.

1. Assignments, 2. Models/ Presentations, 3. multiple choice questions test, 4. Quiz

**Sample Assessment Pattern:**

| Assessment Pattern Level No. | Knowledge Level | ISE 1 | ISE III Assignment | End Semester Examination |
|---|---|---|---|---|
| K3 | Apply | 10 | | 20 |
| K4 | Analyze | 10 | 10 | 20 |
| K5 | Evaluate | | 10 | 20 |
| **Total Marks 100** | | 20 | 20 | 60 |

**Designed by**

**Dr. Sunanda Ghanegaonkar**

| EEDIS5120: Dissertation Phase- I | |
|---|---|
| **Teaching Scheme** | **Examination Scheme** |
| Practical: 4 Hrs/Week | Term Work : 50 Marks |
| Credits :2 | Viva-voce :50 Marks |
| | Total : 100 Marks |

Students will present seminars on the dissertation work carried out as a part of term work. The department will constitute a committee of three members to evaluate the presentation. The committee will have the following structure.

1. Head of the department
2. Guide- Member
3. Subject expert from institute/industry-member

The committee will monitor the quality of the dissertation work.

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## Semester III

| EEM course EEEEM5101: Energy Audit and Management | |
|---|---|
| **Teaching Scheme** | **Examination Scheme** |
| Lectures: 2 Hrs/Week | ISE I : 10 Marks |
| Tutorial: 0 Hrs/Week | ISE II : 10 Marks |
| Credits : 02 | End-Semester Examination : 30 Marks |
| | Total marks :50 Marks |

**Course Objectives:**

After completing the course, students will able to:

| | |
|---|---|
| CO1 | describe the concept of energy management and various regulations related to energy conservation |
| CO2 | demonstrate the significance of energy audit |
| CO3 | apply the different methods used for the economic analysis of energy projects |
| CO4 | appraise the significance of energy efficient & demand- side management of electricity |

**Detailed Syllabus:**

| | |
|---|---|
| **Unit 1** | **Energy Scenario and Management:**<br>An overview of Indian Energy Scenario, Sector Wise Energy Consumption in India, Energy needs of Growing Economy, Long Term Energy Scenario for India. Reasons to save energy (both financial and environmental), Energy Conservation and its importance, Energy Conservation Act and related policies, Bureau of Energy Efficiency(BEE)Regulations. Need to Manage Energy, Definition and objectives of Energy Management, Components of Energy Management program and their explanation. |
| **Unit 2** | **Energy Audit:**<br>Energy audit concepts, Scope of energy audit, types of energy audit, general procedure for a detailed energy audit, various energy audit methodologies, instruments and metering for energy audit, general procedure for a detailed energy audit, preparation of detailed energy audit report, benefits of energy audit. Case study of energy audit in different industrial organizations / electrical utilities. |
| **Unit 3** | **Utility Rate Structures and Financial Analysis:**<br>Understanding Energy Costs, Innovative rates, Real Time Pricing Rates, Financial incentive rates, Energy Purchase Rates. Basic concept of Economic Analysis–Interest Rate, Inflation rate, Single Payment, Uniform–Series Payment. Economic Evaluation Methods – Net Present Worth, Rate of Return, Benefit – Cost Ratio, Payback period. Comparison of Various Economic Evaluation Methods. |
| **Unit 4** | **Energy Efficiency & Demand Side Management:**<br>Introduction,EnergyEfficientMotor,AdjustableSpeedDrives,EnergySavingCalculations, Energy Efficient Lighting Systems, High Efficiency Fluorescent Lamps, Compact Fluorescent Lamps, Cost Effectiveness of Efficient Lightning Technologies ,Automatic Power factor Controllers, HVAC system, Role of New Equipment and Technology in Industrial Energy Efficiency.<br>Introduction to Demand Side Management, Integrated Resource Planning Concepts, Relation between Demand Side Management and Integrated Resource Planning, Demand Side Management Programs, Cost Benefit Analysis of Demand Side Management |

**Text and Reference Books**


1. Smith C.B. Energy Management Principles, Pergamon Press, New York.
2. WayneC.Turner,SteveDoty,EnergyManagementHandbook,TaylorandFrancisLtd.,CRCPress.
3. FrankKreith,Goswami.Yogi,EnergyManagementandConservationHandbook,TaylorandFrancis Ltd., CRC Press.
4. Albert Thumann, Terry Niehus, WilliamJ. Younger, Handbook of Energy Audits, Taylor and Francis Ltd., CRC Press.
5. Rajive Shanker,EnergyAuditinginElectricalUtilities,VivaBookPvt.Limited,NewDelhi.
6. BureauofEnergyEfficiency,GeneralAspectsofEnergyManagementandEnergyAudit.New Delhi.


**ISE III Assessment:** Teachers Assessment of 20 marks is based on **attendance** of the student and one of the / or combination of few of following.

1. Presentation on latest topics/Real life problems related with the subject
2. Simulations problems
3. Quiz
4. MCQ

**Assessment Pattern:**

| **Assessment Pattern Level No.** | **Knowledge Level** | **ISE I** | **ISE III Assignment** | **End Semester Examination** |
|---|---|---|---|---|
| K2 | Understand | 05 | | 10 |
| K3 | Apply | 05 | 05 | 10 |
| K4 | Analyze | | 05 | 10 |
| K5 | Evaluate | | | |
| K6 | Create | | | |
| **Total Marks 50** | | 10 | 10 | 30 |

| **IKS course EEIKS5101: Vedic Approach to Mathematics** | |
|---|---|
| **Teaching Scheme** | **Examination Scheme** |
| Lectures: 2 Hrs/Week | ISE I : 10 Marks |
| Tutorial: 0 Hrs/Week | ISE II : 10 Marks |
| Credits : 02 | End-Semester Examination : 30 Marks |

Understand traditional Indian approaches to energy generation, utilization, and conservation.

- Examine sustainable practices embedded in Indian knowledge traditions.
- Analyze indigenous technologies from the perspective of modern energy engineering.
- Explore integration of traditional wisdom with contemporary sustainable energy systems.

**Course description:** This course is planned as Ability enhancement course. It is an exposure to the Engineering students about vedic Mathematics. Vedic Mathematics is a collection of Techniques/Sutras to solve mathematical arithmetics in easy and faster way. It consists of 16 Sutras (Formulae) and 13 sub-sutras (Sub Formulae) which can be used for problems involved in arithmetic, algebra, geometry, calculus, conics. By using Vedic maths, the problems are solved mentally with the use of few or some of steps which increase accuracy and reduce mistakes. Through the application of the sutras, it ensures both speed and accuracy and enhances computational skills. In this course some of the topics from Vedic Mathematics are introduced which are use full to Engineering Students.

Course Objectives:

The main objectives of the course are:

1. Multiply two or three digits numbers.
2. Compute the division by two and three digit divisors.
3. Check the divisibility by two or three digit numbers without actual division.
4. Evaluate square, cubes, square roots and cube roots of larger numbers within no time.
5. To factorise the quadratic expressions of single variable.
6. To find the Solution of Linear Simultaneous Equations

## Course Outcomes

After completing the course, students will be able to:

| | |
|---|---|
| CO1 | Do multiplication and division of two and three digit numbers by applying Sutras in Vedic Mathematics |
| CO2 | To factorize and find LCM/HCF of numbers by applying Sutras in Vedic Mathematics |
| CO3 | To solve Simultaneous Linear Equations by applying Sutras in Vedic Mathematics |

**Detailed Syllabus:**

| | |
|---|---|
| **Unit 1** | **Multiplication :**<br>1. Ekadhikenpurven method (multiplication of two numbers of two digits)<br>2. Eknunenpurven method (multiplication of two numbers of three digits)<br>3. Urdhvatiragbhyam method (multiplication of two numbers of three digits)<br>4. Nikhilam Navtashchramam Dashtaha (multiplication of two numbers of three digits)<br>**Division and Divisibility :**<br>Part A: Division<br>1. Nikhilam Navtashchramam Dashtaha (two digits divisor)<br>2. Paravartya Yojyet method (three digits divisor)<br>Part B: Divisibility<br>1. Ekadhikenpurven method (two digits divisor)<br>2. Eknunenpurven method (two digits divisor) **Factorization /LCM/HCF** |
| **Unit 2** | **Solution of Linear Simultaneous Equations :**<br>Simple equations, Simultaneous Simple Equations, Quadratic Equations, Cubic Equations, Simultaneous Quadratic Equations. |
| **Unit 3** | **Power and Root Power :**<br>(i) Square (two digit numbers), (ii) Cube (two digit numbers).<br>(iii) Square root (four digit number) (iv) Cube root (six digit numbers)<br>[Self Study and assignments] |

## Text and Reference Books


1. Vedic Mathematics,Jagadguru Swami Sri BHARATI KRSNA TIRTHAJI MAHARAJA, Motilal Banarsi Das Publishing House, New Delhi.
2. Vedic Ganita: Vihangama Drishti-1, Siksha Sanskriti Uthana Nyasa, New Delhi.
3. Vedic Ganita Praneta, Siksha Sanskriti Uthana Nyasa, New Delhi.
4. Vedic Mathematics: Past, Present and Future, Siksha Sanskriti Uthana Nyasa, New Delhi.
5. Leelavati, Chokhambba Vidya Bhavan, Varanasi.
6. Bharatiya Mathematicians, Sharda Sanskrit Sansthan, Varanasi


## Assessment:

| | |
|---|---|
| **ISEI:** | Shall be based on Class Tests/ Assignments/Quizzes/Presentations/ Course Projects |
| **ISEII:** | Shall be based on class test. |

**Mapping of Course outcome Program Outcomes**

| Course Outcome | PO I | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO1 0 | PO1 1I | POI 2 | PSO I | PSO 2 | PSO 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COI | | | | | | | | | | | | | | | |
| CO2 | | | | | | | | | | | | | | | |
| CO3 | | | | | | | | | | | | | | | |

**Assessment Pattern**

| Assessment Pattern Level No. | Knowledge Level | ISE1 | ISEII | ESE |
|---|---|---|---|---|
| K2 | Understand | 05 | 05 | 10 |
| K3 | Apply | 05 | 05 | 10 |
| K4 | Analyze | - | - | 10 |
| KS | Evaluate | - | - | - |
| K6 | Create | - | - | - |
| **Total Mars 50** | | 10 | 10 | 30 |

**Assessment table**

| Assessment Tool | K2 | K2 | K2 |
|---|---|---|---|
| | COl | CO2 | CO3 |
| ISE I (10Marks) | 10 | - | - |
| ISE II (10Marks) | - | 10 | - |
| ESE (30Marks) | 10 | 10 | 10 |

**Prof. S.P. Attipamalu**

| EEDIS5120: DISSERTATION PHASE – II | | |
|---|---|---|
| **Teaching Scheme** | **Examination Scheme** | |
| Practical : 16 Hrs | TW | : 50 Marks |
| Credits :08 | ESE Viva-voce | : 50 Marks |
| | Total | : 100 Marks |

Students will present seminars on the dissertation work carried out as a part of term work. The department will constitute a committee of three members to evaluate the presentation. The committee will have the following structure.

1. Head of the department
2. Guide- Member
3. Subject expert from institute/industry-member

The committee will monitor the quality of the dissertation work.

**Semester IV**

| INT EEINT5101 : Internship/ Industrial Training | |
|---|---|
| **Teaching Scheme**<br>Theory : 0Hrs/Week<br>Credits :2 Hrs/ week | **Examination Scheme**<br>ISE III :50Marks<br>ESE :50 Marks<br>Total :100 Marks |

**As per Institute policy**

**Course Description:** Industrial training(In-Plant Training/Internship) refers to work experience done during the program of study that is relevant to professional development prior to graduation. The training will provide an industrial exposure to the students and opportunity to develop as per the expectations and requirement of industry giving a good start of the career.

The students shall study the technology, processes, practices and work culture in the industry during the training. They shall also work on the project, if allotted. A faculty from the institute and one mentor from the industry will guide the students. The training period will be of minimum 90 working days.

ISE I, II and III: The evaluation is done through reviews. The student has to present his work during the internship. Every candidate has to give a presentation in presence of faculty members and students. The Head of the department will appoint two internal examiners to assess the term work; guide shall be one of the examiners. The student has to prepare typed report of about 25 pages or more, on the work carried out in the respective industry.

**Course Outcomes:**

| | |
|---|---|
| **CO1** | Observe & experience the practices, processes and work culture of the industry |
| **CO2** | Apply engineering concepts to solve the problems |
| **CO3** | Develop employability skills and attitude |

**Mapping of Course outcome with Program Outcomes:**

| **Program Outcome** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **PSO1** | **2** | **3** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | | | | | | 1 | 1 | 1 | 2 | 2 | 2 | 1 | 1 | 1 |
| **CO2** | 3 | 3 | 3 | 3 | | | | | | | | 3 | 3 | 3 |
| **CO3** | | | | | | 1 | 1 | 1 | 3 | 2 | 2 | | | |

**1 – Low 2 – Medium 3 -High**

**Assessment Table:**

| **Assessment Tool** | **K2** | **K2** | **A3** |
|---|---|---|---|
| | **CO1** | **CO2** | **CO3** |
| **ISE III (50 Marks)** | 20 | 20 | 10 |
| **ESE (50 Marks)** | 40 | 40 | 20 |