Semester- I

ADVANCED COMPUTATIONAL METHODS IN POWER SYSTEMS			
Course Code	22EPS12	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	03:02:00	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 10-12 Lab slots	Total Marks	100
Credits	04	Exam Hours	

Course objectives:

MODULE-1	
Introduction, Concept of incidence matrix, formation of A and Â matrices, list of other types of incidence matrices and their limitations. Representation of Generator, Transmission lines and Transformers, Primitive and Network matrices, Y-bus formation by Inspection method and its algorithm. Merits and Demerits of Ybus and Z-bus matrices in Power System Analysis – Areas of application.	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos , NPTEL ,VTU E-learning resources ,
MODULE-2	
Introduction to Load Flow Analysis – Y-bus based Power System Static Load Flow Equations. Gauss-Seidel (GS) method, PV-bus treatment, Gauss-Seidel load flow algorithm. Need of Sparsity technique for 'well-grown' power systems, Concept of Sparsity technique, Y-bus formation using Sparsity technique. GS with Sparsity technique, Merits and Demerits of GS method.	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos , NPTEL ,VTU E-learning resources ,
MODULE-3	
Newton-Raphson (NR) load flow method and its algorithm. Merits and Demerits of NR method; Newton's Decoupled, Fast Decoupled equation, algorithm of Fast Decoupled (FDC) method. Merits and Demerits of FDC method; Areas of application of load flow study. AC/DC load flow solutions.	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos , NPTEL ,VTU E-learning resources
MODULE-4	
Distribution system Load Flow methods-Vector based load flow method, Backward-Forward Sweep method and Current injection method Load flow studies with Renewable Energy Sources; Solar and Wind Energy Sources. Need of short circuit studies – Assumptions in short circuit studies – Areas of application.	
Teaching-Learning Process	Chalk and talk, Power point presentation, NPTEL ,VTU E-learning resources ,Videos
MODULE 5	
Formation of Z-bus using step-by-step approach (Addition of a branch & Addition of a link). Modification of Z-bus elements for changes. Symmetrical Sequence Components, significance of symmetrical components, approximations, formation of primitive z^{abc}, y^{abc}, z^{012} and y^{012} for various types of faults Formation of z_{bus}^{012} by step-by-step algorithm. Derivation of relevant equations for E^{012} for LLLG and LG faults.	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos, NPTEL ,VTU E-learning resources ,

PRACTICAL COMPONENT OF IPCC *(May cover all / major modules)*

Sl.NO	Experiments
1	Solution of Simultaneous Algebraic equations by Gauss Elimination – Crout's method and Cholesky method
2	Solution of Simultaneous differential equations by Range Kutta–4 and Modified Euler's method
3	Program to read and print out the power system load flow data of 5 BUS and 10 BUS Systems
4	Program to read and print out the power system load flow data of– IEEE 14 Bus and IEEE 30 Bus systems
5	Formation of YBUS using two dimensional arrays by inspection method
6	Formation of YBUS using Sparsity Technique
7	Load flow studies by Gauss-Seidel method using two– dimensional arrays – sparsity techniques
8	Newton Raphson method based Load flow studies by using two – dimensional arrays – sparsity techniques
9	Fast Decoupled Load flow method using two – dimensional arrays – sparsity techniques
10	Distribution system load flow using backward forward method
11	**Can be Demo experiments for CIE**
12	**Can be Demo experiments for CIE**

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

CIE for the theory component of IPCC

1. Two Tests each of **20 Marks**
2. Two assignments each of **10 Marks/One Skill Development Activity of 20 marks**
3. Total Marks of two tests and two assignments/one Skill Development Activity added will be CIE for 60 marks, marks scored will be proportionally scaled down to **30 marks**.

CIE for the practical component of IPCC

- On completion of every experiment/program in the laboratory, the students shall be evaluated and marks shall be awarded on the same day. The**15 marks** are for conducting the experiment and preparation of the laboratory record, the other **05 marks shall be for the test** conducted at the end of the semester.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to 15 marks.
- The laboratory test at the end /after completion of all the experiments shall be conducted for 50 marks and scaled down to 05 marks**.**

Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **20 marks**.

SEE for IPCC

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (duration 03 hours)

1. The question paper will be set for 100 marks and marks scored will be scaled down proportionately to 50 marks.
2. The question paper will have ten questions. Each question is set for 20 marks.
3. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
4. The students have to answer 5 full questions, selecting one full question from each module.

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper shall include questions from the practical component).

- The minimum marks to be secured in CIE to appear for SEE shall be the 15 (50% of maximum marks-30) in the theory component and 10 (50% of maximum marks -20) in the practical component. The laboratory component of the IPCC shall be for CIE only. However, in SEE, the questions from the laboratory component shall be included**.** The maximum of 04/05 questions to be set from the practical component of IPCC, the total marks of all questions should not be more than the 20 marks.
- SEE will be conducted for 100 marks and students shall secure 40% of the maximum marks to qualify in the SEE. Marks secured will be scaled down to 50. (Student has to secure an aggregate of 50% of maximum marks of the course(CIE+SEE)

Suggested Learning Resources:

Books

1. Computer Methods in Power System Analysis, Stagg and El – Abiad , McGraw Hill, ISE, 1986
2. Computer techniques in Power System Analysis, M A Pai and Dr. Dheeman Chatterjee, McGraw hill, 2014, 3e
3. Power System Analysis, Hadi Sadat, McGraw Hill – International Edition – 1999
4. Computer Modeling of Electrical Power Systems, J. Arrilaga and NR Watson, John Wiley and Sons, 2001, 1e

Web links and Video Lectures (e-Resources):

1. Website reference links: https://www.engineeringonline.ncsu.edu/course/ece-753-computational-methods-for-power-systems/
2. https://www.youtube.com/playlist?list=PL36A60B630E8C7B56
3. https://www.youtube.com/playlist?list=PL-uxPiMl0_6GWFPGXgVapb1yjVAZs9YGz
4. **https://nptel.ac.in/courses/108107028**

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

Course Outcomes:

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

CO1	Develop mathematical models for load flow studies for Transmission and Distribution systems and Fault analysis
CO2	Prepare the input data required for load flow analysis and fault calculations
CO3	Develop computer programs (MATLAB, Power World) to solve power flow problems Decoupled Power Flow, Fast Decoupled Power Flow, DC Power Flow Optimal power flow
CO4	Apply appropriate algorithms for Distribution systems load flow studies
CO5	Develop power system software /implementation of algorithm for static power system studies

Semester- I

ANALYSIS OF POWER CONVERTERS			
Course Code	**22EPS13**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	**3:0:2**	SEE Marks	50
Total Hours of Pedagogy	**50**	Total Marks	100
Credits	**4**	Exam Hours	

Course Learning objectives:

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Module-1	
Overview of Switching Power Devices: Static and dynamic characteristics of switching devices: BJT, MOSFET, IGBT, GTO,Wide band gap devices (GaN, SiC) - Design of driver and snubber circuit	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos, NPTEL ,VTU E-learning resources ,
Module-2	
DC-DC Converters: Non-isolated DC-DC converters: buck, boost, buck-boost, CUK converters under continuous and discontinuous conduction operation - Isolated DC-DC converters: forward, fly-back, push-pull, half-bridge and full-bridge converters - Relationship between I/P and O/P voltages- design of filter inductor and capacitors	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos, NPTEL ,VTU E-learning resources ,
Module-3	
Inverters: Single-phase and three-phase inverters- PWM techniques: single, multiple and sinusoidal PWM techniques- selective harmonic elimination, space vector modulation, current source inverter- High power inverters: Multi-pulse inverters, multi-level inverters - Diode-clamped, cascaded and Flying capacitor types, Carrier and Vector based multi-level modulation schemes -Concept of active power filters	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos, NPTEL ,VTU E-learning resources ,
Module-4	
Front-End (AC-DC) Converters: Conventional methods of power factor improvements: Semi-converter, extinction angle control, symmetrical angle control – active front-end converters- Single phase: Boost, voltage doubler and PWM rectifiers – voltage and current controlled three-phase PWM rectifiers	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos, NPTEL ,VTU E-learning resources ,
Module-5	
AC/DC/AC Converters: Introduction, AC/DC/AC converters used in wind turbine systems, New AC/DC/AC converters, AC/DC/AC boost-type converters, Two-level AC/DC/AC ZSI. Three- level diode-clamped AC/DC/AC converter, linking a wind turbine system to a utility network. **DC/AC/DC Converters:** Chopper type DC/AC/DC converters, Switched capacitor DC/AC/DC converters- single stage and three stages. Simulation exercise using MATLAB/SIMULINK.	
Teaching-Learning Process	Chalk and talk, Power point presentation, NPTEL ,VTU E-learning resources , Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Power Electronics Handbook, M.H. Rashid, Butterworth-Heinemann, 2017, 4th edition
2. Power Electronics: Converters, Applications & Design**,** N Mohan, T.M. Undeland, WP.Robbins**,** John Wiley & Sons, 2003, 3rd edition
3. Power Electronics: Essentials and Applications, Umanand, L, John Wiley India, 2009, 1st Edition
4. Fundamentals of Power Semiconductor Devices, Jayant Baliga B, Springer, 2008, 1st Edition
5. Fang Lin Luo Hong Ye, **"Power Electronics Advanced Conversion Technologies",** 1st edition, CRC Press Taylor & Francis Group, 2018.
6. M.H.Rashid, **"Power Electronics Circuits, Devices & Applications",** 3rd edition, P.H.I. Pearson, New Delhi, 2002.
7. Narayanaswamy P. R. Iyer**, "Power Electronic Converters Interactive Modelling Using Simulink",** CRC Press Taylor & Francis Group, 2018.

Web links and Video Lectures (e-Resources):

https://nptel.ac.in/courses

https://swayam.gov.in/explorer https://swayam.gov.in/nc_details/NPTEL

Skill Development Activities Suggested

Course Outcomes:

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

CO1	Select appropriate switching devices for power converters
CO2	Analyze and design power converter configurations for specific applications
CO3	Select control techniques for low and medium power converters
CO4	Design power electronic converters to improve power quality
CO5	Describe the operations of AC/DC/AC and DC/AC/DC conversion technologies.

Semester- I

HIGH VOLTAGE & ELECTRICAL INSULATION ENGINEERING			
Course Code	22EPS14	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	

Course Learning objectives:

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Module-1

INTRODUCTION: ELECTRIC FIELDS, THEIR CONTROL AND ESTIMATION-I

Electric Charge and Discharge, Electric and Magnetic Fields and Electromagnetics, Dielectric and Electrical Insulation, Electrical Breakdown, Global Breakdown, Local Breakdown, Corona, Streamer and Aurora, Capacitance and Capacitor,

Stray Capacitance, Electric Field Intensity, "E", Breakdown and Electric Strength of Dielectrics, "Eb", Classification of Electric Fields, Control of Electric Field Intensity (Stress Control), Estimation of Electric Field Intensity. Analysis of Electric Field Intensity in Isotropic Multidielectric System, Basic Equations for Potential and Field Intensity in Electrostatic Fields.	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos, NPTEL ,VTU E-learning resources ,
Module-2	
ELECTRIC FIELDS, THEIR CONTROL AND ESTIMATION-I Analytical Methods for the Estimation of Electric Field Intensity in Homogeneous Isotropic Single Dielectric, Direct Solution of Laplace Equation. Analysis of Electric Field Intensity in Isotropic Multidielectric System, Field with Longitudinal Interface, Field with Perpendicular Interface, Numerical Methods for the Estimation of Electric Field Intensity, Finite Element Method (FEM) Charge Simulation Method (CSM), Numerical Optimization of Electric Fields, Optimization by Displacement of Contour Points, Optimization by Changing the Positions of Optimization Charges, and Contour Points, Optimization by Modification of Contour Elements	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos, NPTEL ,VTU E-learning resources ,
Module-3	
ELECTRICAL PROPERTIES OF VACUUM AS HIGH VOLTAGE INSULATION **Pre-breakdown Electron Emission in Vacuum**: Mechanism of Electron Emission from Metallic Surfaces Non-Metallic Electron Emission Mechanisms **Pre-Breakdown Conduction and Spark Breakdown in Vacuum:** Electrical Breakdown in Vacuum Interrupters, High Current Arc Quenching in Vacuum Delayed Re-Ignition of Arcs Effect of Insulator Surface Phenomena. Effect of Conditioning of Electrodes on Breakdown Voltage, Effect of Area of Electrodes on Breakdown in Vacuum.	
Teaching-Learning Process	Chalk and talk, NPTEL ,VTU E-learning resources ,Power point presentation, Videos, NPTEL ,VTU E-learning resources ,
Module-4	
LIQUID DIELECTRICS, THEIR CLASSIFICATION, PROPERTIES AND BREAKDOWN STRENGTH **Classification of Liquid Dielectrics** : Mineral Insulating Oils, Mineral Insulating Oil in Transformers, Vegetable Oils ,Synthetic Liquid Dielectrics, the Chlorinated Diphenyles, Halogen Free Synthetic Oils, Inorganic Liquids as Insulation**,** Polar and Nonpolar Dielectrics, **Dielectric Properties of Insulating Materials:** Insulation Resistance Offered by Dielectrics, Permittivity of Insulating Materials, Polarization in Insulating Materials, Effect of Time on Polarization, Polarization under Direct Voltage, Polarization under Alternating Voltage, Dielectric Power Losses in Insulating Materials, **Breakdown in Liquid Dielectrics**: Electric Conduction in Insulating Liquids, Liquid Dielectrics in Motion and Electro hydrodynamics, Intrinsic Breakdown Strength, Practical Breakdown Strength Measurement at Near Uniform Fields, Effect of Moisture and Temperature on Breakdown Strength, Breakdown in Extremely Non-uniform Fields and the Development of Streamer, **Aging in Mineral Insulating Oils**	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos, NPTEL ,VTU E-learning resources ,
Module-5	
SOLID DIELECTRICS, THEIR SOURCES, PROPERTIES AND BEHAVIOR IN ELECTRIC FIELDS **Classification of Solid Insulating Materials:** Inorganic Insulating Materials, Ceramic Insulating Materials, Glass as an Insulating Material, Polymeric Organic Materials. **Partial Breakdown in Solid Dielectrics** , Internal Partial Breakdown, Surface Discharge (Tracking) Degradation of Solid Dielectrics Caused by, Inhibition of Partial Breakdown/Treeing in Solid Dielectrics, Partial Breakdown Detection and Measurement , Indirect Methods of PB Detection, Direct Methods of PB Detection and Measurement, **Breakdown and Pre-Breakdown Phenomena in Solid Dielectrics,** Intrinsic Breakdown Strength of Solid Dielectrics, Thermal Breakdown, Mechanism of Breakdown in Extremely Nonuniform Fields, "Treeing" a Pre-Breakdown Phenomenon in Polymeric Dielectrics, Forms of Treeing Patterns, Classification of Treeing Process, Requirement of Time for Breakdown, Estimation of Life Expectancy Characteristics, Practical Breakdown Strength and Electric Stress in Service of Solid Dielectrics	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos, NPTEL ,VTU E-learning resources ,

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1.R. Arora and W. Mosch, "High Voltage and Electrical Insulation Engineering", Wiley-IEEE press

2 N. H. Malik, A. A. Al-Arainy and M. I. Qureshi, "Electrical Insulation in Power System", Marcel Dekker Inc.

3. A. Haddad and D. F. Warne, "Advances in High Voltage Engineering", Institution of Engineering and Technology

4. R. E. James and Q. Su, "Condition Assessment of High Voltage Insulation in Power System Equipment", The Institution of Engineering and Technology

5. S. Chakravorti, D. Dey and B. Chatterjee, "Recent Trends in the Condition Monitoring of Transformers", Springer-Verlag

6. S. Chakravorti, "Electric Field Analysis", CRC Press (Taylor & Francis)

Web links and Video Lectures (e-Resources):

- https://archive.nptel.ac.in/courses/108/104/108104048/
- Online web portal **http://nptel.ac.in**
- **YouTube channel for NPTEL – most subscribed educational channel**

Skill Development Activities Suggested

Course outcomes

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

CO1	Understand the basic physics related to various breakdown processes in Dielectric, Electrical Insulation and Isotropic Multidielectric System.
CO2	Learn different Numerical field estimation methods for Homogeneous Isotropic Single & Multi dielectric Systems
CO3	Understand Pre-breakdown Electron Emission, Conduction and Spark Breakdown in Vacuum
CO4	Understand Classification & dielectric properties of liquid insulating materials
CO5	Understand Classification & dielectric properties of Solid insulating materials

Semester- I

Power Systems Stability and Control			
Course Code	**22EPS15**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

Module-1

Synchronous Machine Modeling:
Parks transformation of flux linkages – Voltage – Current equations and physical interpretation; dq0 equivalent circuits; Synchronous – transient – sub–transient and operational impedances; time constants – Power and torque field & armature current due to sudden short circuit; Phasor diagrams

Teaching-Learning Process	Chalk and talk, NPTEL ,VTU E-learning resources ,Power point presentation, Videos

Module-2

Basic Models For Power System Studies
Low and high order models; excitation systems; exciter voltage regulator models; Hydraulic and steam turbine models; Low frequency oscillation studies – action of proportional and forced action AVR

Teaching-Learning Process	Chalk and talk, NPTEL ,VTU E-learning resources ,Power point presentation, Videos

Module-3

Steady State and Dynamic Stability Studies
Normal conditions – steady state stability criteria of single and multi– machine systems – practical stability criteria; Dynamic stability of SMIB system with the aid of Phillips-Heffron model, design of PSS for SMIB system

Teaching-Learning Process	Chalk and talk, NPTEL ,VTU E-learning resources ,Power point presentation, Videos

Module-4

Transient Stability Studies:
Stability analysis of multi machine systems – Effect of exciter and governor models – Computer solution and flow charts

Teaching-Learning Process	Chalk and talk, NPTEL ,VTU E-learning resources ,Power point presentation, Videos

Module-5

Methods To Improve Rotor Angle Stability:
Methods to improve steady state, dynamic and transient stability of power systems. Voltage stability.

Teaching-Learning Process	Chalk and talk, NPTEL ,VTU E-learning resources ,Power point presentation, Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources: Books

1. Power System Control and Stability, P.M. Anderson & A.A. Fouad: Willey IEEE Press, 2003
2. Power Systems stability and Control, Prabha Kundur: McGraw – Hill Inc. 2006, Indian edition
3. Power System Dynamics Stability and Control, K R Padiyar: BS Publications, Hyderabad, 2008
4. 2. Power system stability, M. A. Pai and Peter W. Sauer, Pearson Education, 2006

Web links and Video Lectures (e-Resources):

Online Resources:

1. Website reference links: https://nptel.ac.in/courses/108/106/108106026/
2. https://www.youtube.com/playlist?list=PLuv3GM6-gsE2WXbxLSnqKHf5gcnedXCZH.

Skill Development Activities Suggested

Course outcomes

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

CO1	Develop mathematical models of power system for dynamic studies
CO2	Analyze the performance of single and multi-machine systems under transient, steady and dynamic conditions
CO3	Design stabilizers, dynamic resistors and SMES for the power system
CO4	Identify the methods to improve dynamic & transient stability of power systems
CO5	Analyze Rotor angle stability and Voltage stability of Power systems.

Semester- I

Research Methodology and IPR			
Course Code	22RMI16	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50

Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

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Module-1	
Teaching-Learning Process	Chalk and talk method / PowerPoint Presentation, NPTEL ,VTU E-learning resources , Experimental learning, Problem based learning
Module-2	
Teaching-Learning Process	Chalk and talk method / PowerPoint Presentation, NPTEL ,VTU E-learning resources , Experimental learning, Problem based learning
Module-3	
Teaching-Learning Process	Chalk and talk method / PowerPoint Presentation, NPTEL ,VTU E-learning resources , Experimental learning, Problem based learning
Module-4	
Teaching-Learning Process	Chalk and talk method / PowerPoint Presentation, NPTEL ,VTU E-learning resources , Experimental learning, Problem based learning
Module-5	

Teaching-Learning Process	Chalk and talk method / PowerPoint Presentation, NPTEL ,VTU E-learning resources , Experimental learning, Problem based learning

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1) Three Unit Tests each of **20 Marks**
2) Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1) The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2) The question paper will have ten full questions carrying equal marks.
3) Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.

Suggested Learning Resources:Text Books

Reference Books:

1.

Web links and Video Lectures (e-Resources):

Skill Development Activities Suggested:

1) Interact with industry (small, medium, and large).
2) Involve in research/testing/projects to understand their problems and help creative and innovative methods to solve the problem.
3) Involve in case studies and field visits/ fieldwork.
4) to the use of standards/codes etc., to narrow the gap between academia and industry.
5) Handle advanced instruments to enhance technical talent.
6) Gain confidence in modelling of systems and algorithms for transient and steady-state operations, thermal study, etc.
7) Accustom Work on different software/s (tools) to simulate, analyze and authenticate the output to interpret and conclude.

All activities should enhance student's abilities to employment and/or self-employment opportunities, management skills, Statistical analysis, fiscal expertise, etc.

Students and the course instructor/s to involve either individually or in groups to interact together to enhance the learning and application skills of the study they have undertaken. The students with the help of the course teacher can take up relevant technical –activities which will enhance their skill. The prepared report shall be evaluated for CIE marks.

Semester-1

POWER SYSTEMS & POWER CONVERTERS LABORATORY

Course Code	22EPSL17	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	1:2:0	SEE Marks	50
Credits	02	Exam Hours	03

Course objectives:

The power system lab will be comprising of at least TWO experiments from each of the subjects 22XXX12 to 22XXX15 EXCEPT 22XXX14 such as representation of Power System Elements like Synchronous machines, transformers, transmission lines, loads, power system load flow, short circuit studies and power system stability studies using MATLAB-SIMULINK, PSCAD, CAPS software. Study of power semiconductor devices; study AC to DC, DC to DC converter circuits etc using software, design as well as by building up the circuits in laboratories. Renewable energy systems.

Sl.NO	Experiments
	POWER CONVERTERS
1	Analysis of DC-DC converters (a) Buck converter, (b) Boost converter, and (c) Buck- Boost converter
2	Closed loop control of Buck and Boost converter
3	Unipolar and bipolar PWM techniques for single-phase half-bridge inverters
4	Unipolar and bipolar PWM techniques for single-phase full-bridge inverters
5	Single phase Five level cascaded H-Bridge inverter
	Power Systems (This Lab Shall be Comprising of at least 5 Experiments from Part-A & 3 Experiments from Part-B)
	PART-A
6	To perform AC-DC Power flow analysis on 5 Bus systems with HVDC transmission line using PSCAD/POWER WORLD/SCI-LAB/MAT-LAB/…
7	To carry out Short Circuit studies on a given Power System using PSCAD/POWER WORLD/SCI-LAB/MAT-LAB/…
8	MVAR Compensation studies on normal and heavily loaded power systems using PSCAD/POWER WORLD/SCI-LAB/MAT-LAB/…
9	Transient Stability Analysis of Power Systems using PSCAD/POWER WORLD/SCI-LAB/MAT-LAB/…
10	Contingency evaluation and analysis of power system using simulation package
11	To perform State Estimation and bad data detection for a given Power System.
12	Fault studies using Zbus matrix
	PART-B
13	Determination of Sequence Impendence of an Alternator by direct method.
14	Determination of Sequence impedance of an Alternator by fault Analysis.
15	Measurement of sequence impedance of a three phase transformer
16	Power angle characteristics of a salient pole Synchronous Machine.
17	Poly-phase connection on three single phase transformers and measurement of phase Displacement.
	Demonstration Experiments (For CIE) if any
1	Study the characteristics of IGBT, MOSFET & GTO's. Design of gate drive circuits for IGBT & MOSFET's.
2	Study of 1-ϕ square wave and sinusoidal PWM inverter. Study of 3-ϕ inverter with 120o and 180o mode of operation. Study of 3-ϕ sinusoidal PWM inverter.
3	Determination of input p.f. and harmonic factor for 3-ϕ full converter & for 3-ϕ semi converter (Inductive load).
4	Reactive Power Control Using Tap Changing Transformer
5	Regulation and efficiency characteristics of Artificial Transmission Line
6	Determination of Sequence Reactance's of Power System Elements (Alternator & 3- Φ Transformer)
7	Analysis of unbalanced voltages using Symmetrical Component Analyser
8	Short circuit studies using DC Network Analyser

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each course. The student has to secure not less than 40% of maximum marks in the semester-end examination (SEE). In total of CIE and SEE student has to secure 50% maximum marks of the course.

Continuous Internal Evaluation (CIE):

CIE marks for the practical course is **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment to be evaluated for conduction with observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments designed by the faculty who is handling the laboratory session and is made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- Total marks scored by the students are scaled downed to 30 marks (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct 02 tests for 100 marks, the first test shall be conducted after the 8th week of the semester and the second test shall be conducted after the 14th week of the semester.
- In each test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- The average of 02 tests is scaled down to **20 marks** (40% of the maximum marks).

The Sum of **scaled-down** marks scored in the report write-up/journal and average marks of two tests is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

SEE marks for the practical course is 50 Marks. SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the University. All laboratory experiments are to be included for practical examination. (Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.

Students can pick one question (experiment) from the questions lot prepared by the internal /external examiners jointly. Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners. General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners) Change of experiment is allowed only once and 10% Marks allotted to the procedure part to be made zero. The duration of SEE is 03 hours

Suggested Learning Resources:

Semester – II

EHV AC TRANSMISSION

Course Code	**22EPS21**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

Module-1

Introduction to EHV AC Transmission: Calculations of line and ground parameters: Properties of bundled conductors, inductance and capacitance calculations line parameters for modes of propagation resistance and inductance of ground returns, equivalent circuit of line model

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-2

Voltage Gradients of Conductors: Electrostatics, Field of Sphere, Field of Line Charges and Their , Charge-Potential Relations for Multi-Conductor, Surface Voltage Gradient on Conductors, Examples of Conductors and Maximum Gradients on Actual Lines, Gradient Factors and Their Use, Distribution of Voltage Gradient on Sub-conductors of Bundle

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-3

Corona and Radio interference: corona loss formula factors affecting corona. Audible noise, its characteristics, limits for audio noise, relation between single phase and 3-phase AN levels, radio interference, limits for radio interference fields, CIGRE formula

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-4

Over Voltage in EHV Systems: Switching surges, causes of switching surge over voltages, recovery voltage, Restriking transients, over voltages caused by interruption of low inductance currents, line energization transients, Ferro-resonance over voltages, lightning over voltages, protection against switching and lightning surges, VFTO in GIS, insulation coordination, design example

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-5

Power System Grounding: Functional Requirements of Earthing System, Equipment Earthing, Neutral Point Earthling, design of Substation grounding System, analysis of simple grounding systems, dimensioning of Earth Conductors, Step Potential and Touch Potential, body currents due to touch and step voltages, grounding system safety assessment and Earth Mat design. Measurement of Resistance and Soil Resistivity of Earthing System

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources: Books:

1. Extra High Voltage AC Transmission Engineering, Rakesh Das Begamudre, New Age International publishers, 2014, Fourth Edition
2. Power Generation Operation & Control, Allen J Wood & Bruce Wollenberg, 2016, Third Edition
3. Electric Power Transmission System Engineering Analysis and Design, Turan Gonen, CRC Press, 2014, Third Edition
4. Power Systems Grounding, Md. Abdus Salam, Quazi M. Rahman, Springer publishers, 2016
5. 3. Performance, Operation and Control of EHV Power Transmission Systems, A Chakraborti, D.P. Kothari and A.K. Mukhopadyay, T.M.H. (Pub) 1992

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/channel/UCWKPXSjLRz-TAFgFWCfMmGg/videos

Skill Development Activities Suggested

Course Outcomes:

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

CO1	Evaluate parameters of EHV line modelling
CO2	Analyze Voltage Gradients of Conductors & Distribution of Voltage Gradient on Sub-conductors of Bundle
CO3	Understand the over-voltage phenomena and methods to limit in EHV AC systems
CO4	Analyze and evaluate electric field and interference characteristics of EHV AC system
CO5	Design grounding system for EHVAC systems

Semester – II

DIGITAL PROTECTION OF POWER SYSTEMS			
Course Code	22EPS22	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	03:02:00	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 10-12 Lab slots	Total Marks	100
Credits:	04	Exam Hours	3 hours

Course objectives:

MODULE-1

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

PRACTICAL COMPONENT OF IPCC *(May cover all / major modules)*

Sl.NO	Experiments
1	Simulation of Relaying Algorithms for numerical protection.
2	3-ϕ Differential Relay.
3	To Observe Trip Time of Microcontroller Based Over/Under Frequency Relay.
4	To Observe Trip Time of Microcontroller Based Reverse Power Relay
5	General Considerations on Protection Devices
6	Protection of Transmission lines using Digital Relays.
7	Checking the Operation the Protection Devices with Differential Current.
8	Selectivity among Protection Devices.
11	**Can be Demo experiments for CIE**
12	**Can be Demo experiments for CIE**

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

CIE for the theory component of IPCC

1. Two Tests each of **20 Marks**
2. Two assignments each of **10 Marks/One Skill Development Activity of 20 marks**
3. Total Marks of two tests and two assignments/one Skill Development Activity added will be CIE for 60

marks, marks scored will be proportionally scaled down to **30 marks**.

CIE for the practical component of IPCC

- On completion of every experiment/program in the laboratory, the students shall be evaluated and marks shall be awarded on the same day. The**15 marks** are for conducting the experiment and preparation of the laboratory record, the other **05 marks shall be for the test** conducted at the end of the semester.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to 15 marks.
- The laboratory test at the end /after completion of all the experiments shall be conducted for 50 marks and scaled down to 05 marks**.**

Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **20 marks**.

SEE for IPCC

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (duration 03 hours)

1. The question paper will be set for 100 marks and marks scored will be scaled down proportionately to 50 marks.
2. The question paper will have ten questions. Each question is set for 20 marks.
3. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
4. The students have to answer 5 full questions, selecting one full question from each module.

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper shall include questions from the practical component).

- The minimum marks to be secured in CIE to appear for SEE shall be the 15 (50% of maximum marks-30) in the theory component and 10 (50% of maximum marks -20) in the practical component. The laboratory component of the IPCC shall be for CIE only. However, in SEE, the questions from the laboratory component shall be included**.** The maximum of 04/05 questions to be set from the practical component of IPCC, the total marks of all questions should not be more than the 20 marks.
- SEE will be conducted for 100 marks and students shall secure 40% of the maximum marks to qualify in the SEE. Marks secured will be scaled down to 50. (Student has to secure an aggregate of 50% of maximum marks of the course(CIE+SEE)

Suggested Learning Resources:

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
5. Understanding Digital Signal Processing, Orhan Gazi, Springer, 2017, 2/e
6. Fundamentals of Power System Protection, Paithankar Y.G, PHI, 2010, 2/e
7. Protective Relays-their Theory and Practice, A R C Warrington, Chapman & Hall Ltd., 1968

Web links and Video Lectures (e-Resources):

Online Resources:

1. https://onlinecourses.nptel.ac.in/noc20_ee73/preview
2. NPTEL :: Electrical Engineering - Power System Protection (web contents)
3. NPTEL :: Electrical Engineering - NOC:Power System Protection and Switchgear (video lectures)

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

Course Outcomes:

At the end of the course, te student 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	Identify the new developments in protective relaying and applications
CO5	Apply Fuzzy Logic and ANN for Wide Area Monitoring and Protection

Semester- II-------Professional Electives-1

RESTRUCTURED POWER SYSTEMS			
Course Code	**22EPS231**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

Module-1

Restructuring of power industry and Fundamentals of Economics: Introduction, Reasons for restructuring / deregulation of power industry, Fundamentals of Deregulation, Motivation of restructuring the power industries, restructuring process – unbundling & privatization, restructuring models, Components of restructured systems. **Transmission Pricing :**Cost components, Postage Stamp Method, Megawatt Mile Method, Contract Path Method

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-2

Smart Grid in Power Market:
Independent System Operator (ISO): Functions and responsibilities, Smart Grid trading arrangements (Pool, bilateral & multilateral), Open Access Transmission Systems, and Open Access Same time Information system (OASIS), Definitions transfer capability issues: ATC, TTC, TRM, CBM calculations, methodologies to calculate ATC, Electricity Pricing.

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-3

Smart Grid Bidding Strategies: Forward and Future market; Operation and control: Old vs New, Integrated bidding strategy in smart multi energy system, Smart grid Optimization with risk constraints-General risk measures, Portfolio selection problem, penalty formulation.
Transmission Congestion Management: Classification of congestion management methods, Calculation of ATC-TTC-CBM, Non-market methods, Market based methods, Nodal pricing, Inter-zonal Intra-zonal congestion management, Price area congestion management.

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-4

Demand Response in Smart Grid: Demand response, Potential benefits of demand response in smart grid, enabling smart technologies for demand response, control devices for demand response, Monitoring and communication system. Demand response for Electric Vehicles, Examples: Ancillary Services within Smart Grid framework: Reactive power as an ancillary services, Energy Storage System, Power Quality, Reliability analysis.

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-5

Smart Grid Economic and market operations: Energy and Reserve Markets, Market Power, Generation Firms, Locational Marginal Prices, Financial Transmission Rights. Concepts of block chain technologies in energy trading and power purchase agreements (PPA).

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each modul

Suggested Learning Resources:

Books

1. Power System Restructuring and Deregulation, L. L. Lai, John Wiley & Sons Ltd., 2012, 1st Edition.
2. Operation of restructured power systems, K. Bhattacharya, J. E. Daadler, and Math H.J Bollen, Kluwer Academic Pub., 2012, 1st Edition (Reprint).
3. Fundamentals of Power System economics, D. Kirschen and G. Strbac, John Wiley & Sons Ltd, 2019, 2nd Edition.
4. Making competition work in electricity, S. Hunt, John Wiley & Sons, Inc., 2002, 1st Edition.
5. Power System Deregulation: Loss Sharing in Bilateral Contracts and Generator Profit Maximization, Ashikur Bhuiya: Publisher VDM Verlag, 2008
6. 3. Restructured Electrical Power Systems, Mohammad Shahidehpour and Muwaffaqalomoush, Marcel Dekker, Inc., 2001, 1st Edition

Web links and Video Lectures (e-Resources):

1. NPTEL – Restructured Power Systems – Prof. S.A. Khaparde, Dr. A.R. Abhyankar, IIT Delhi
2. www.isgf.com , www.iexindia.com , www.posoco.in , http://www.ferc.fed.us
3. http://www.nordpool.no
4. http://www.statnett.no
5. http://www.ofaem.gov.uk
6. http://www.caiso.com
7. http://www.nationalgrid.com
8. http://www.bmreports.com/bwx_home.htm

Skill Development Activities Suggested

Course Outcomes:

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

CO1	Understand the need for restructured power system and economics.
CO2	Understand Transmission Pricing, Smart Grid in Power Market & Bidding Strategies
CO3	Analyze transmission congestion and Estimate loss allocation in Power System
CO4	Analyze demand response in smart grid systems
CO5	Evaluate economics and ancillary services within the Smart Grid

Semester- II

DISTRIBUTION SYSTEM PLANNING AND AUTOMATION			
Course Code	**22EPS232**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	

Course Learning objectives:

Module-1

Distribution System Planning: Planning and forecasting techniques – Present and future – Role of computers- Load Characteristics- Load forecasting using ANN – Load management – tariffs and metering of energy

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-2

Distribution Transformers: Types – Three phase and single phase transformers – connections – causes and types of failures in distribution transformers

Primary distribution systems and Distribution Sub–Stations: Distribution substations –Bus schemes – comparison of switching schemes- Substation location and rating- Types of feeders – voltage levels

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-3

Voltage Drop and Power Loss Calculations: Three phase primary lines – Copper loss – Distribution feeder costs – Loss reduction and Voltage improvement in rural networks

Capacitors In Distribution Systems: Effects of series and shunt capacitors – justification for capacitors – Procedure to determine optimum capacitor size and location

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-4

Distribution System Automation: Reforms in power sector – Methods of improvement – Reconfiguration – Automation – Communication systems – Sensors –Basic architecture of Distribution automation system – software and open architecture – RTU and Data communication – SCADA requirement and application functions – Communication media for distribution system automation- Communication protocols for Distribution systems – IEC 61850 and IEEE 802.3 standards

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-5

Distribution system management: Integrated sub–station metering system – Revenue improvement – issues in multi–year tariff and availability based tariff

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Electric Power Distribution, Automation, Protection and Control, James A Momoh, CRC press, 2001
2. Electric Power Distribution, A. S. PABLA, TMH,2000
3. Electric Power Distribution Engineering, Turan Gonen, Mc-Graw Hill,1986
4. A Textbook of Electric Power Distribution Automation, Dr. M.K. Khedkar, Dr. G.M. Dhole, Laxmi Publications Ltd., 2010

Web links and Video Lectures (e-Resources):

https://www.youtube.com/channel/UCWKPXSjLRz-TAFgFWCfMmGg/videos

Skill Development Activities Suggested

Course Outcomes:

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

CO1	Understand and distinguish characteristics of distribution systems from transmission systems
CO2	Understand causes and types of failures in distribution transformers
CO3	To design, analyse and evaluate distribution system design based on forecasted data
CO4	Identify and select appropriate sub–station location
CO5	Design and evaluate a distribution system for a given geographical service area from alternate design alternatives

Semester- II

POWER SYSTEM PLANNING AND RELIABILITY			
Course Code	**22EPS233**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	

Course Learning objectives:

Module-1

Generating System Reliability Analysis – I. Generation system model – capacity outage probability tables – Recursive relation for capacitive model building – sequential addition method – unit removal – Evaluation of loss of load and energy indices – Examples

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-2

Generating System Reliability Analysis – II

Frequency and Duration methods – Evaluation of equivalent transitional rates of identical and non-identical units – Evaluation of cumulative probability and cumulative frequency of non-identical generating units – 2-level daily load representation - merging generation and load models – Examples

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-3

Operating Reserve Evaluation: Basic concepts - risk indices – PJM methods – security function approach – rapid start and hot reserve units – Modelling using STPM approach. Bulk Power System Reliability Evaluation. Basic configuration – conditional probability approach – system and load point reliability indices – weather effects on transmission lines – Weighted average rate and Markov model – Common mode failures

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-4

Inter Connected System Reliability Analysis :Probability array method – Two inter connected systems with independent loads – effects of limited and unlimited tie capacity - imperfect tie – Two connected Systems with correlated loads – Expression for cumulative probability and cumulative frequency

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-5

Distribution System Reliability Analysis – I (Radial configuration) :Basic Techniques – Radial networks – Evaluation of Basic reliability indices, performance indices – load point and system reliability indices – customer oriented, loss and energy oriented indices – Examples

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources: Books:

1. Reliability Evaluation of Power Systems, Roy Billinton and Ronald N. Allan, Plenum press, New York and London, 1996 Second Edition
2. Reliability Modeling in Electric Power Systems, J. Endrenyi, John Wiley and Sons, 1978, First Edition
3. Electricity Economics & Planning, T. W. Berrie, Peter Peregrinus Ltd., London
4. Power System Planning, R.L. Sullivan, Tata McGraw Hill Publishing Company Ltd .

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/watch?v=sbZ2sY_E4QU

Skill Development Activities Suggested

Course Outcomes:

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

CO1	Understand the importance of maintaining reliability of power system components
CO2	Apply the probabilistic methods for evaluating the reliability of generation and transmission systems
CO3	Assess the different models of system components in reliability studies
CO4	Assess the reliability of single area and multi area systems
CO5	Understand the Reliability Analysis of Distribution System of Radial configuration

Semester-II

FLEXIBLE AC TRANSMISSION SYSTEMS			
Course Code	**22EPS234**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	**2:0:2**	SEE Marks	50
Total Hours of Pedagogy	**40**	Total Marks	100
Credits	**03**	Exam Hours	

Course Learning objectives:

Module-1

Introduction: Need for power system interconnections, Evolution of AC and DC transmission systems, Comparison of HVDC and HVAC Transmission systems, Power flow in AC systems, Relative importance of controllable parameters, Basic types of FACTS controllers, shunt and series controllers. Overview of power

converters used in FACTS controllers

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-2

Objectives of shunt compensation, Methods of controllable VAR generation, Static Var Compensator, its characteristics, TCR, TSC, FC-TCR configurations, STATCOM, basic operating principle, control approaches and characteristics

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-3

Objectives of series compensator, variable impedance type of series compensators, switching converter type compensators, TCSC, TSSC- operating principles and control schemes, SSSC, Power Angle characteristics, Control range and VAR rating

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-4

Static Phase Angle Regulators – power flow control by phase angle regulator and improvement of transient stability

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-5

Introduction to Unified Power Flow Controller, Basic operating principles, Conventional control capabilities, Control structure of UPFC, Interline power flow controller

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources: Books:

1. Flexible AC Transmission Systems (FACTS), Yong Hua Song & Allan T Johns, IEE power and energy series, 2008
2. Understanding FACTS – Concepts and Technology of Flexible AC Transmission Systems, NarainG.Honorani, Laszlo Gyugyi, Wiley-IEEE Press, 1999
3. FACTS Controllers in Power Transmission and Distribution, K.R. Padiyar, New Age International Publishers, 2016
4. Thyristor- Based FACTS controllers for electrical transmission systems, R. Mohan Mathur and Rajiv K. Varma, IEEE Press, 2002

Web links and Video Lectures (e-Resources):

https://www.youtube.com/playlist?list=PLLy_2iUCG87AVyRAN4QwVQrC8vSg1vWa6

https://nptel.ac.in/courses/108/107/108107114/

Skill Development Activities Suggested

Course Outcomes:

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

CO1	Understand the need for control of Real and Reactive power flows
CO2	Identify the objectives of series and shunt compensation of power systems
CO3	Analyse the performance of Series, Shunt and combined FACTS controllers
CO4	Evaluate the performance and stability of power systems with FACTS controllers
CO5	Understand Static Phase Angle Regulators – power flow control by phase angle regulator

Semester- II

POWER SYSTEM TRANSIENTS			
Course Code	**22EPS235**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	

Course Learning objectives:

Module-1

Introduction and survey: Review of various types of power system transients – effect of transients on power systems –relevance of the study and computation of power system transients.

Lighting surges: Electrification of thunderclouds – lightning current surges – lightning current parameters and their values –stroke to tower and midspan – induced lightning surges.

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-2

Switching transients -Damping circuits -Abnormal switching transients Three-phase circuits and Transients. Computation of power system transients -Principle of digital computation – Matrix method of solution- Modal analysis- Z transform- Computation using EMTP

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-3

Lightning, switching and temporary over voltages: Lightning: Physical phenomena of lightning –Interaction between lightning and power system – Influence of tower footing resistance and earth Resistance- Switching: Short line or kilometric fault – Energizing transients - closing and re-closing of lines - line dropping, load rejection – over voltages induced by fault – Switching HVDC line

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-4	
Reflection, Refraction, Behaviour of Travelling waves at the line terminations – Lattice Diagrams –Attenuation and Distortion – Multi-conductor system and Velocity wave.	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos
Module-5	
Insulated Substation (GIS)- co-ordination between insulation and protection level – statistical approach- Protective devices- Protection of system against over voltages– lightning arresters, substation Earthing.	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

1. Allan Greenwood, Electrical transients in Power Systems, Wiley Interscience, New York, 1971.
2. Klaus Ragaller, Surges in High Voltage Networks, Plenum Press, New York, 1980.
3. Diesendrof W., Over Voltages On High Voltage Systems, Renselaer Bookstore, Troy New York, 1971.
4. Peterson H.A., transients in power systems, Dover Publications, New York, 1963.
5. Rakosh Das Begamudre, Extra High VoltageAC Transmission Engineering, Wiley Estern Itd, New Delhi, 1990.

Web links and Video Lectures (e-Resources):

https://nptel.ac.in/courses/108105104
https://onlinecourses.nptel.ac.in/noc22_ee18/preview
https://onlinecourses.nptel.ac.in/noc21_ee110/preview

Skill Development Activities Suggested

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Course Outcomes:

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

CO1	Acquire knowledge on generation of switching transients and their control.
CO2	Understand and analyse switching and lightning transients.

CO3	Understand Energizing transients - closing and re-closing of lines - line dropping, load rejection – over voltages induced by fault – Switching HVDC line
CO4	Understand the importance of propagation, reflection and refraction of travelling waves.
CO5	Understand co-ordination between insulation and protection level of insulated substation(GIS)

Semester- II--------Professional Electives-2

APPLICATION OF POWER ELECTRONICS TO POWER SYSTEM			
Course Code	**22EPS241**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	

Course Learning objectives:

Module-1

Review of semiconductor devices, Steady state and dynamic problems in AC systems, Power flow, Flexible AC transmission systems (FACTS): Basic realities & roles, Types of facts controller, Principles of series and shunt compensation.

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-2

Description of static VAR compensators (SVC), Thyristor Controlled series compensators (TCSC), Static phase shifters (SPS), Static condenser (STATCON), Static synchronous series compensator (SSSC) and Unified power flow controller (UPFC).

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-3

Modelling and Analysis of FACTS controllers. Control strategies to improve system stability. Power Quality problems in distribution systems.

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-4

Harmonics, harmonics creating loads, modelling, Series and parallel resonances, harmonic power Flow, Mitigation of harmonics, filters, passive filters.

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-5

Active filters shunt, series hybrid filters, voltage sags & swells, voltage flicker. Mitigation of power Quality problems using power electronic conditioners. IEEE standards.

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources: Books

1. Understanding of FACTs. Hingorani, N. G.; IEEE Press 1996.
2. Power Quality. Heydt G.T.; Stars in a Circle Publications , Indiana, 1991.
3. Static Reactive Power Compensation.; Miller T.J.E.; John Wiley & Sons, New York, 1982
4. Flexible AC Transmission System. (FACTs).;Yong Hua Song.; IEE 1999.

Web links and Video Lectures (e-Resources):

https://nptel.ac.in/courses/108107128
https://onlinecourses.nptel.ac.in/noc20_ee97/preview
https://onlinecourses.nptel.ac.in/noc22_ee127/preview
https://onlinecourses.nptel.ac.in/noc21_ee01/preview
https://archive.nptel.ac.in/noc/courses/noc19/SEM1/noc19-ee03/
https://onlinecourses.nptel.ac.in/noc22_ee17/preview

Skill Development Activities Suggested

Course Outcomes:

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

CO1	Understand the concept of FACTs
CO2	Select and implement proper compensator to solve the problems occurring power Transmission
CO3	Model and analyze the FACT controllers
CO4	Understand and apply the active filtering techniques in mitigation of harmonic distortion
CO5	Know/Learn IEEE Standards for Mitigation of power quality problems using power electronic conditioners

Semester-II

MODERN OPTIMISATION TECHNIQUES IN POWER SYSTEM.			
Course Code	**22EPS242**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	

Course Learning objectives:

Module-1

FUNDAMENTALS OF OPTIMIZATION Definition-Classification of optimization problems-Unconstrained and Constrained optimization- Optimality conditions-Classical Optimization techniques (Linear and non-linear programming, Quadratic programming, Mixed integer programming)-Intelligent Search methods (Optimization neural network, Evolutionary algorithms, Tabu search, Particle swarm optimization, Application of fuzzy set theory).	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos
Module-2	
EVOLUTIONARY COMPUTATION TECHNIQUES Evolution in nature-Fundamentals of Evolutionary algorithms-Working Principles of Genetic Algorithm-Evolutionary Strategy and Evolutionary Programming-Genetic Operators-Selection, Crossover and Mutation-Issues in GA implementation- GA based Economic Dispatch solution-Fuzzy Economic Dispatch including losses-Tabu search algorithm for unit commitment problem-GA for unit commitment-GA based Optimal power flow- GA based state estimation.	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos
Module-3	
PARTICLE SWARM OPTIMIZATION Fundamental principle-Velocity Updating-Advanced operators-Parameter selection- Hybrid approaches (Hybrid of GA and PSO, Hybrid of EP and PSO) -Binary, discrete and combinatorial PSO-Implementation issues-Convergence issues- PSO based OPF problem and unit commitment-PSO for reactive power and voltage control-PSO for power system reliability and security.	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos
Module-4	
ADVANCED OPTIMIZA TION METHODS Simulated annealing algorithm-Tabu search algorithm-SA and TS for unit commitment-Ant colony optimization-Bacteria Foraging optimization.	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos
Module-5	
MULTI OBJECTIVE OPTIMIZATION Concept of pareto optimality-Conventional approaches for MOOP-Multi objective GA-Fitness assignment-Sharing function-Economic Emission dispatch using MOGA-Multiobjective PSO (Dynamic neighbourhood PSO, Vector evaluated PSO) –Multiobjective OPF problem.	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources: Books

1. D.P.Kothari and J.S.Dhillon, "Power System Optimization", 2ndEdition, PHI learning private limited, 2010.
2. Kalyanmoy Deb, "Multi objective optimization using Evolutionary Algorithms" , John Wiley and Sons, 2008.
3. Kalyanmoy Deb, "Optimization for Engineering Design",Prentice hall of India first edition,1988.
4. Carlos A.Coello Coello, Gary B.Lamont, David A.Van Veldhuizen, "Evolutionary Algorithms for solving Multi Objective Problems", 2ndEdition, Springer, 2007.
5. SolimanAbdel Hady,Abdel Aal Hassan Mantawy, "Modern optimization techniques with applications in Electric Power Systems" ,Springer,2012.
6. Jizhong Zhu," Optimization of power system operation",John Wiley and sons Inc publication,2009.
7. Kwang Y.Lee,Mohammed A.El Sharkawi, "Modern heuristic optimization techniques", John Wiley and Sons,2008.

Web links and Video Lectures (e-Resources):

https://nptel.ac.in/courses/108101040
https://onlinecourses.nptel.ac.in/noc22_ee35/preview
https://nptel.ac.in/courses

Skill Development Activities Suggested

Course Outcomes:

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

CO1	Understand the theoretical workings of the simplex method for linear programming and perform iterations of it by hand.
CO2	Perform sensitivity analysis to determine the direction and magnitude of change of a model's optimal solution as the data change.
CO3	Solve specialized linear programming problems like the transportation and assignment problems.
CO4	Solve network models like the shortest path, minimum spanning tree, and maximum flow problems.
CO5	Model a dynamic system as a queuing model and compute important performance Measures

Semester-II

CONTROL AND INTEGRATION OF RENEWABLE ENERGY SOURCES			
Course Code	**22EPS243**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	

Course Learning objectives:

Module-1	
Introduction: Electric grid, Utility ideal features, Supply guarantee, power quality, Stability and cost; Importance & Effects of Renewable Energy penetration into the grid, Boundaries of the actual grid configuration, Consumption models and patterns.	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-2	
Dynamic Energy Conversion Technologies: Introduction, types of conventional and nonconventional dynamic generation technologies, principle of operation and analysis of reciprocating engines, gas and micro turbines, hydro and wind based generation technologies.	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-3	
Static Energy Conversion Technologies: Introduction, types of conventional and nonconventional static generation technologies; Principle of operation and analysis of fuel cell, photovoltaic systems and wind generation technologies; MPPT techniques and its classifications, principle of operation and partial shading effects; Storage Technologies -batteries, fly wheels, super capacitors and ultra-capacitors.	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-4	
Control Issues and Challenges: Linear and nonlinear controllers, predictive controllers and adaptive controllers, Load frequency and Voltage Control, PLL, Modulation Techniques, Control of Diesel, PV, wind and fuel cell based generators, Dimensioning of filters, Fault-ride through Capabilities.	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-5	
Integration of Energy Conversion Technologies: Introduction & importance, sizing, Optimized integrated systems, Interfacing requirements, Distributed versus Centralized Control, Grid connected Photovoltaic systems – classifications, operation, merits & demerits; Islanding Operations, stability and protection issues, load sharing, operation & control of hybrid energy systems, Solar Photovoltaic applications. IEEE & IEC standards for renewable energy grid integrations.	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources: Books

1. Renewable and Efficient Electric Power Systems, G. Masters, IEEE-John Wiley and Sons Ltd. Publishers, 2013, 2nd Edition.
2. Microgrids and Active Distribution Networks, S. Chowdhury, S. P. Chowdhury, P. Crossley, IET Power Electronics Series, 2012.
3. Integration and Control of Renewable Energy in Electric Power System, Ali Keyhani Mohammad Marwali and Min Dai, John Wiley publishing company, 2010, 2nd Edition.
4. Fundamentals, technologies & Applications, Chetan Singh Solanki, Solar Photovoltaic, PHI Publishers, 2019, 3rd Edition.
5. Control of Power Inverters in Renewable Energy and Smart Grid Integration, Quing-Chang Zhong, IEEE-John Wiley and Sons Ltd. Publishers, 2013, 1St Edition.
6. Power Conversion and Control of Wind Energy Systems, Bin Wu, Yongqiang Lang, Navid Zargari, IEEE- John Wiley and Sons Ltd. Publishers, 2011, 1st Edition.
7. Report on "Large Scale Grid Integration of Renewable Energy Sources - Way Forward" Central Electricity Authority, GoI, 2013.

Web links and Video Lectures (e-Resources):

https://nptel.ac.in/courses/103103206
https://archive.nptel.ac.in/courses/108/107/108107113/
https://www.youtube.com/watch?v=cGHlV0EavaQ
https://www.youtube.com/watch?v=sob03s6d5_s
https://www.digimat.in/nptel/courses/video/108107113/L01.html

Skill Development Activities Suggested

Course Outcomes:

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

CO1	Understand the actual configuration of electric grid, its utilization and various scenarios related to the grid.
CO2	Understand the process of power generation by renewable energy sources and the configuration of various dynamic energy systems.
CO3	Understand the static generation technologies, its classification and various forms of energy storage and their importance.
CO4	Acquire knowledge on types of controllers and modulation techniques in order to deal with the different control issues.
CO5	Analyse the performance of grid connected system. Understand the various standards and quality issues for grid integration. Know IEEE & IEC standards for renewable energy grid integrations.

Semester- II

HIGH VOLTAGE DC TRANSMISSION			
Course Code	**22EPS244**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	

Course Learning objectives:

Module-1

DC Power Transmission Technology: Introduction, Comparison of AC&DC Transmission, Applications of DC Transmission, Description of DC Transmission System, Modern Trends in DC Transmission

HVDC with Current Source Converters. Analysis of HVDC Converters: Choice of converter configuration, Simplified analysis of Graetz circuit: without overlap, with overlap, Converter Bridge characteristics. Equivalent circuit of HVDC link, power factor and reactive power of converters

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-2

Converter And HVDC System Control: Principles of DC link control ,Converter control characteristics, power reversal in DC link, voltage dependent current order limit(VDCOL), System control hierarchy, Firing angle control , constant current control and Extinction angle control, Power control

LCC HVDC System Harmonics: Harmonic Performance Criteria, Harmonic Limits, Harmonic Filters, Non-characteristic Harmonic Reduction Using HVDC Controls

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-3

HVDC with Voltage Source Converters

VSC HVDC Applications and Topologies, Performance and Cost Comparison with LCC HVDC: Voltage Source Converters (VSC), Comparison with Line-Commutated Converter (LCC) HVDC, Overhead and Subsea/Underground VSC HVDC Transmission, DC Cable Types with VSC HVDC, Monopolar and Bipolar VSC HVDC Systems, VSC HVDC Converter Topologies, VSC HVDC Station Components, AC Reactors, DC Reactors

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-4

Two-Level PWM VSC HVDC Modelling, Control and Interaction with AC Systems: Various Two-Level Converter Models, VSC Converter Control Principles, Complete VSC Converter Controller. Power Exchange between Two AC Voltage Sources , Converter Phasor Model and Power Exchange with an AC System and Operation with Very Weak AC Systems

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-5

VSC HVDC under AC and DC Fault Conditions and applications: Introduction, DC Faults with Two-Level VSC, Influence of DC Capacitors, VSC Converter Modelling under DC Faults conditions. VSC HVDC High-Level Controls and AC Grid Support, HVDC Embedded AC Grid, HVDC Connecting Two Separate AC Grids, HVDC in Parallel with a Passive AC System and VSC HVDC Operation with Offshore Wind Farms

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources: Books

1. HVDC Power Transmission System, K.R. Padiyar: New Age Intl. Co, 2015
2. High Voltage Direct Current Transmission: Converters, Systems and DC Grids, Dragan Jovcic, Khaled Ahmed, Wiley Publishers, 2015
3. Direct Current Transmission, Edward Wilson Kimbark, Vol-1, John Wiley & Sons, 1971
4. Self-Commutating Converters for High Power Applications, Jos Arrillaga, Yonghe H. Liu, Neville R. Watson, Nicholas J. Murray, Wiley Publishers, 2009
5. HVDC Transmission: Power Conversion Applications in Power Systems, Chan-Ki Kim, Vijay K. Sood, Gil-Soo Jang, Seong-Joo Lim, Seok-Jin Lee, Wiley Publishers 2009

Web links and Video Lectures (e-Resources):

Online Resources:

1. Website reference links: https://www.youtube.com/playlist?list=PL4B78E9972172086A
2. https://nptel.ac.in/courses/108104013
3. https://www.classcentral.com/course/youtube-electrical-high-voltage-dc-transmission-47611

Skill Development Activities Suggested

Course Outcomes:

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

CO1	Understand the basic concepts and recent trends in HVDC transmission system and its applications.
CO2	Know about the basic HVDC transmission equipment and the system control against harmonics produced within the system.
CO3	Understand the classification of VSC HVDC transmission and different components associated with the VSC HVDC station.
CO4	Configure VSC HVDC system, study various converter models and know the interaction between HVAC and HVDC system.
CO5	Study the various protection schemes of HVDC engineering and modelling of converters under different fault conditions.

Semester-II

POWER QUALITY IMPROVEMENT TECHNIQUES			
Course Code	**22EPS245**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	

Course Learning objectives:

Module-1

Power Quality: 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.

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.

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-2

Harmonic Sources: Introduction; 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;

Effects of Harmonic Distortion: Introduction; 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.

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-3

Harmonic Elimination: Introduction; 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

Voltage Quality: Introduction; 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.

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-4

Methods for improving Voltage Quality: Introduction; Dynamic Voltage Restorer (DVR): Operating principle, Configurations, State of the art, Design and control strategies. Three-phase four-wire DVR.

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-5

Unified Power Quality Conditioner (UPQC): Introduction; design and control; Three-phase three-wire UPQC and three-phase four-wire UPQC topologies, Multilevel inverters based UPQC topologies, Mitigation of Flicker.

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books:

1. Power Quality: Problems and Mitigation Techniques, Bhim Singh, Ambrish Chandra, Kamal Al-Haddad, Wiley, 2015.
2. Understanding power quality problems, Math H.J. Bollen, Wiley-IEEEPress,2000, 1stEdition.
3. Power Quality Enhancement Using Custom Power Devices, Ghosh Arindam, Ledwich Gerard, Springer,2009.
4. Instantaneous Power Theory and Applications to Power Conditioning, Hirofumi Akagi, Edson Hirokazu Watanabe, Mauricio Aredes, Wiley-IEEEPress,2017.
5. Electrical Power Systems Quality, Roger C. Dugan, Mark F. Mc Granaghan, Surya Santoso and H. Wayne Beaty, McGrawHill, 2012, 3rdEdition.
6. Power System Harmonics, J. Arrillaga, N.R.Watson, Wiley,2003, 2ndEdition.

Web links and Video Lectures (e-Resources):

Online Resources:

1. https://nptel.ac.in/courses/108/107/108107157/
2. https://nptel.ac.in/courses/108/106/108106025

Skill Development Activities Suggested

Course Outcomes:

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

CO1	Know the importance of power quality. Understand the different power quality issues. Analyse the distortion waveforms.
CO2	Study the generation of harmonics from different electrical equipment and its effect on other connected instruments.
CO3	Understand the configuration of different filters for the minimization of harmonics, factors affecting the voltage quality, classification of voltage sag, magnitude calculation and its effect.
CO4	Acquire the knowledge on different methods to improve the voltage quality, configuration of DVR.
CO5	Study the design of UPQC, its different topologies.

SEMESTER-II

PROTECTION & H V LABORATORY			
Course Code	**22EPSL26**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	2:0:2	SEE Marks	50
Credits	2	Exam Hours	03

Course objectives:

Sl.NO	Experiments
	PROTECTION LABORATORY
1	To test and analyse Feeder protection schemes using a laboratory prototype of a transmission feeder.
2	To test and analyse Generator protection schemes using a laboratory prototype.
3	To test and analyse Motor protection schemes using a laboratory prototype
4	To study the Negative phase sequence protection scheme on testing kit.
5	To Plot Trip Time Characteristics of Microprocessor Based Over/Under Voltage Relay.
6	To Plot Trip Time Characteristics of Numerical Based Percentage Biased
	H V LABORATORY
1	Study BDV strength test of insulating oils using 100 kV motorized kit & Study BDV strength test for various pressure and vacuum
2	Analysis of Electrostatic Field in a Parallel Plate Capacitor for Single & Multi Dielectrics Using ANSYS Software
3	Analysis of Field Distribution of Dielectric Under Different Electrode Configuration Using ANSYS Software
4	Calibration of sphere gap arrangement for High voltage measurement using Test Transformer
5	Study of capacitance and tan delta of insulating material
6	To Study Breakdown of Air Using 100 kV AC Test Set Using ▪ Sphere – Sphere Gap ▪ Sphere – Plane Gap ▪ Point – Plane Gap
7	Generation of HVDC with the Help of 140 KV, DC Set-Up
8	To Generate and Measure Positive & Negative Lightning Impulse Voltage Waveforms Using 280 KV, 2-Stage, and 1.96 KJ Impulse Test Set. Study of impulse generator. Study the characteristics of impulse voltage and wave shape of lightning impulse voltage.
9	To Generation of Switching Wave Positive & Negative with the Help of Two-Stage, 280 KV Impulse Generators.

Course outcomes (Course Skill Set):

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

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Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each course. The student has to secure not less than 40% of maximum marks in the semester-end examination(SEE). In total of CIE and SEE student has to secure 50% maximum marks of the course.

Continuous Internal Evaluation (CIE):

CIE marks for the practical course is **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment to be evaluated for conduction with observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments designed by the faculty who is handling the laboratory session and is made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- Total marks scored by the students are scaled downed to 30 marks (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct 02 tests for 100 marks, the first test shall be conducted after the 8th week of the semester and the second test shall be conducted after the 14th week of the semester.
- In each test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- The average of 02 tests is scaled down to **20 marks** (40% of the maximum marks).

The Sum of **scaled-down** marks scored in the report write-up/journal and average marks of two tests is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

SEE marks for the practical course is 50 Marks.

SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the University.

All laboratory experiments are to be included for practical examination.

(Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.

Students can pick one question (experiment) from the questions lot prepared by the internal /external examiners jointly.

Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.

General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)

Change of experiment is allowed only once and 10% Marks allotted to the procedure part to be made zero.The duration of SEE is 03 hours

Suggested Learning Resources:

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Semester- III

REAL-TIME CONTROL OF POWER SYSTEMS			
Course Code	**22EPS31**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	50
Total Hours of Pedagogy	50	Total Marks	100
Credits	04	Exam Hours	

Course Learning objectives:

Module-1

STATE ESTIMATION OF POWER SYSTEM:

Introduction to State Estimation (SE) in Power Systems: Weighted Least Square Estimation (WLS-SE). SE of AC networks: Types of measurements, Linear WLS–SE theory, DC Load flow based WLS–SE, Linearized model of WLS–SE of Non–linear AC power systems, typical results of SE on an AC network. Detection and Identification of bad measurements, Network Observability and Pseudo–measurements, optimal meter placement. Incorporation of PMU data in WLS-SE

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-2

SECURITY ANALYSIS OF POWER SYSTEM:

Concept of security, Security analysis and monitoring, Contingency Analysis for Generator and Line Outages by Fast Decoupled Inverse Lemma based approach, Network Sensitivity factors

REAL-TIME CONTROL OF POWER SYSTEMS: Introduction, operating states of a Power System.

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-3

SCADA FUNCTIONS:

Introduction to SCADA: Grid Operation & Control, advantages of SCADA operation. Lay out of substation, Main Equipment's in Sub Station, Instrument Transformers, and necessary parameters for Grid operation: Analog Points, Status Points, Alarms, Transducers & their connectivity

Data Acquisition, Monitoring and Event Processing, Control Functions, Time tagged data, Disturbance data collection and analysis, Reports and Calculations. Man – Machine Communication: Operator's Console, VDU Display, Operator Dialogs, Mimic Diagram Functions. Remote Terminal Unit (RTU), Phase angle Measurement unit (PMU) & Communication Practices Major Components: RTU Panel, Interface Panel, D20M Main Processor, Analog Card, Status Card, Control Card, Modems. Types Of Communications: Power Line Carrier Communications, Microwave, Optical fibre, VSAT Communications. Types of Network Elements in LAN & WAN. Process of Data Communication

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-4

Introduction to SCADA PROTOCOLS and Communication Standards

Evolution of Protocol for Communication, Protocols -Modbus, Distributed Network Protocol (DNP), IEC 870-5 and 60870 series, Benefits from IEC (International Electro technical Commission) communication Standards. **Sub-load Dispatch Centre (Sub- LDC)**

Equipment in Sub LDC: Work Stations, FEPS, Routers, Functionalities of Sub LDC- Real Time Software

Classification of Programs, Structure of Real time Programs, Construction Techniques & Tools, Programming Language Requirements for Process Control

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-5

Overview of Computer control of Electrical Power Systems

Evolution of System Control, time scale of system control, online computer control, and Software Elements: State Estimation, Monitoring & Prediction, Generation & Load Control, Security Analysis; Software Coordination & Systems Simulation. State Load Dispatch Centre (SLDC): Inter Connectivity of Sub-LDCs & SLDCs, Hierarchy of Data Transfer, Functions & Responsibilities of SLDC, Real Time Operation carried at SLDC. Southern Regional Load Dispatch Centres (SRLDC) and National Load Dispatch Centre (NLDC**)-** Functions & Responsibilities of SRLDC, Operations carried at SRLDC, Overview of SCADA, Real Time operation in detail Operations carried out NLDC

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Assessment Details (both CIE and SEE)

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Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources: Books

1. Power System Generation, Operation and Control, Allen J. Wood, Bruce Wollenberg and Gerald B. Sheble, John Wiley and Sons, 2013, 3rd Edition
2. Power System SCADA and Smart Grids, Mini S. Thomas and John D. McDonald, CRC Press, 2015, 1st Edition
3. Power System Analysis, John J. Grainger and William D Stevenson Jr.: McGraw Hill, 2017, ISE
4. Power System control – Technology, Torsten Cegrell, Prentice –Hall International series in Systems and control Engineering, Prentice Hall International Ltd., 1986
5. Real – Time Computer Control, S. Bennett and D.A. Linkens (Editors): IEE Control Engineering series (24), Peter Peregrinus Ltd., 1984
6. Real – Time Systems, C.M. Krishna and Kangg. Shin: Mc Graw-Hill international companies
7. Special Issue on Computer Control of Power Systems, IEEE Proc. July 1974

Web links and Video Lectures (e-Resources):

https://archive.nptel.ac.in/courses/108/105/108105133/
https://archive.nptel.ac.in/courses/108/105/108105104/
https://onlinecourses.nptel.ac.in/noc22_ee18/preview
https://nptel.ac.in/courses/108107127

Skill Development Activities Suggested

Course Outcomes:

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

CO1	Understand state estimation, security and contingency evaluation.
CO2	Know the importance of security and contingency analysis
CO3	Understand SCADA, its objectives and its importance in power systems, data acquisition.
CO4	Study SCADA protocols, IEC communication standards, sub load dispatch centre.
CO5	Analyse, estimate, control electrical power system and related operations by computer software.

Semester- III-------Professional Elective-3

Computer Relaying and Wide Area Measurement Systems			
Course Code	**22EPS321**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	

Course Learning objectives:

Module-1

Introduction to Computer Relaying

Introduction to DSP, Use of computer relay, Analog to Digital Converters, Sampling, Anti – aliasing filters. Evolution of power system relaying from electromagnetic to static to computer relaying; Relay operating principles for computer relaying; Expected benefits of computer relaying, Computer relay architecture.

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-2

Protection of Transmission Line using Computer Relaying. Three zone protection of transmission line, algorithms for impedance calculations- Mann-Morrison algorithm -Three sample technique - Two sample technique - First and second derivative algorithms – Numerical Integration methods.

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-3

Protection of power system equipment using Frequency domain techniques

Problems associated with differential protection of transformer and bus-bar, magnetic inrush current, LSQ algorithm, Fourier analysis of transformer protection.

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-4

Phasor Measurement Units

Introduction to Phasor measurement units (PMUS), global positioning system (GPS), Functional requirements of PMUs and PDCs, Phasor estimation of nominal frequency inputs

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-5

PMU Applications. Wide Area Measurement Systems (WAMS), WAMS Applications in Smart Grid, WAMS Based Protection Concepts, Adaptive Relaying, State estimation.

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Assessment Details (both CIE and SEE)

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Continuous Internal Evaluation:

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Semester End Examination:

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4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. John G. Prokis and Dimitris G. Hanolakis, 'Digital Signal Processing, Principles, Algorithms & Applications' 4th Edition, Pearson Education, 2006
2. A.G. Phadke, J.S. Thorp, 'Computer Relaying for Power Systems', John Wiley and Sons Ltd., Research Studies Press Limited, 2nd Edition, 2009
3. A.G. Phadke, J.S. Thorp, 'Synchronized Phasor Measurements and Their Applications', Springer Publications, 2008

Web links and Video Lectures (e-Resources):

https://nptel.ac.in/courses/106105183
https://onlinecourses.nptel.ac.in/noc22_ee46/preview

Skill Development Activities Suggested

Course Outcomes:

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

CO1	Know the fundamentals of computer relaying and its applications in wide area measurement systems.
CO2	Study internal architecture and algorithms employed in numerical methods for the protection of transmission line.
CO3	Solve problems related to power system equipment.
CO4	Understand Phasor measurement units, its functions and applications.
CO5	Understand wide area measurement systems and its applications in Smart grid.

Semester- III

EVOLUTIONARY ALGORITHMS APPLICATIONS IN POWER ENGINEERING			
Course Code	**22EPS322**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	
Course Learning objectives:			
Module-1			

Fundamentals of Soft Computing Techniques Definition-Classification of optimization problems- Unconstrained and Constrained optimization Optimality conditions- Introduction to intelligent systems- Soft computing techniques- Conventional Computing versus Swarm Computing - Classification of meta-heuristic techniques - Single solution based and population based algorithms – Exploitation and exploration in population based algorithms - Properties of Swarm intelligent Systems - Application domain - Discrete and continuous problems - Single objective and multi-objective problems.	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos
Module-2	
Genetic Algorithm and Particle Swarm Optimization Genetic algorithms- Genetic Algorithm versus Conventional Optimization Techniques - Genetic representations and selection mechanisms; Genetic operators- different types of crossover and mutation operators -Bird flocking and Fish Schooling – anatomy of a particle- equations based on velocity and positions -PSO topologies - control parameters – GA and PSO algorithms for solving ELD problem without loss, Selective Harmonic Elimination in inverters and PI controller tuning.	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos
Module-3	
Ant Colony Optimization and Artificial Bee Colony Algorithms Biological ant colony system - Artificial ants and assumptions - Stigmergic communications - Pheromone updating-local-global - Pheromone evaporation - ant colony system- ACO models-Touring ant colony system-max min ant system - Concept of Elitist Ants-Task partitioning in honey bees - Balancing foragers and receivers - Artificial bee colony (ABC) algorithms-binary ABC algorithms – ACO and ABC algorithms for solving Economic Dispatch without loss and PI controller tuning.	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos
Module-4	
Shuffled Frog-Leaping Algorithm and Bat Optimization Algorithm Bat Algorithm- Echolocation of bats- Behaviour of micro bats- Acoustics of Echolocation- Movement of Virtual Bats-Loudness and Pulse Emission- Shuffled frog algorithm-virtual population of frogs comparison of memes and genes - memeplex formation- memeplexupdation- BA and SFLA algorithms for solving ELD without loss and PI controller tuning.	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos
Module-5	
Multi Objective Optimization Multi-Objective optimization Introduction- Concept of Pareto optimality - Non-dominant sorting technique-Pareto fronts-best compromise solution-min-max method-NSGA-II algorithm and application to general two objective optimization problems.	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Assessment Details (both CIE and SEE)

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   to attain the COs and POs

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Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
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4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:Books

1. Xin-She Yang, „Recent Advances in Swarm Intelligence and Evolutionary Computation", Springer International Publishing, Switzerland, 2015.
2. Kalyanmoy Deb „Multi-Objective Optimization using Evolutionary Algorithms", John Wiley & Sons, 2001.
3. James Kennedy and Russel E Eberheart, „Swarm Intelligence", The Morgan Kaufmann Series in Evolutionary Computation, 2001.
4. Eric Bonabeau, Marco Dorigo and Guy Theraulaz, „Swarm Intelligence-From natural to Artificial Systems", Oxford university Press, 1999.
5. David Goldberg, „Genetic Algorithms in Search, Optimization and Machine Learning", Pearson Education, 2007.
6. Konstantinos E. Parsopoulos and Michael N. Vrahatis, „Particle Swarm Optimization and Intelligence: Advances and Applications", InformatIonscIence reference, IGI Global, , 2010.
7. N P Padhy, „Artificial Intelligence and Intelligent Systems", Oxford University Press, 2005.
8. ."Shuffled frog-leaping algorithm: a memetic meta-heuristic for discrete optimization" by Muzaffareusuff, Kevin lansey and Fayzul pasha, Engineering Optimization, Taylor & Francis, Vol. 38, No. pp.129–154, March 2006.
9. "A New Metaheuristic Bat-Inspired Algorithm" by Xin-She Yang, Nature Inspired Cooperative Strategies for Optimization (NISCO 2010) (Eds. J. R. Gonzalez et al.), Studies in Computational Intelligence, Springer Berlin, 284, Springer, 65-74 (2010).
10. "Firefly Algorithms for Multimodal Optimization" Xin-She Yang, O. Watanabe and T. Zeugmann (Eds.), Springer-Verlag Berlin Heidelberg, pp. 169–178, 2009.

Web links and Video Lectures (e-Resources):

https://archive.nptel.ac.in/courses/112/103/112103301/
https://onlinecourses.nptel.ac.in/noc22_me47/preview
https://nptel.ac.in/courses/115103104
https://onlinecourses.nptel.ac.in/noc22_ee35/preview

Skill Development Activities Suggested

Course Outcomes:

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

CO1	State and formulate the optimization problem, without and with constraints, by using design variables from an engineering design problem.
CO2	Apply classical optimization techniques to minimize or maximize a multi-variable objective function, without or with constraints, and arrive at an optimal solution.
CO3	Formulate a mathematical model and apply linear programming technique by using Simplex method. Also extend the concept of dual Simplex method for optimal solutions.
CO4	Apply gradient and non-gradient methods to nonlinear optimization problems and use interior or exterior penalty functions for the constraints to derive the optimal solutions.
CO5	Apply Genetic algorithms for simple electrical problems and able to solve practical problems using PSO

Semester- III

ECONOMIC OPERATION OF POWER SYSTEMS			
Course Code	**22EPS323**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

Module-1	
Economic Operation - Economic dispatch problem and methods of solutions – Economic importance – Characteristics of steam units, Economic dispatch of Thermal Units and methods of solutions – problem considering and neglecting transmission losses, Iterative and non-iterative methods of solutions – economic dispatch using dynamic programming	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos
Module-2	
Unit Commitment – Definition – Constraints in Unit Commitment – Unit Commitment solution methods – Priority – List Methods – Dynamic Programming Solution, Economic dispatch versus Unit Commitment – Constraints in thermal and hydro units	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos
Module-3	
Hydro-thermal co-ordination – Hydroelectric plant models – short term hydro thermal scheduling problem – gradient approach – Hydro units in series – pumped storage hydro plants – hydro- scheduling using Dynamic programming and linear programming	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos
Module-4	
Control of generation – Models of power system elements – Modelling of Load Frequency Control (LFC) of single area system and two area systems - with and without PID controllers – static and dynamic analysis – development of state variable model of single area and two area systems – Implementation of Automatic Generation control (AGC) – AGC features	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos
Module-5	
Optimal Power Flow- Introduction-Solution of OPF –gradient method, Newton's method- Leniar Sensitivity analysis -linear programming method- Security Constrained OPF- Interior Point OPF- Bus Incremental Coats	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Assessment Details (both CIE and SEE)

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The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

1. Power Generation Operation and Control, Allen J.Wood and Bruce.F.Wollenberg, John Wiley & Sons, New York, 2016, 2e
2. Electric Energy System Theory – an Introduction, Elgerd.O.I, Tata McGraw Hill, New Delhi, 2013
3. Load Flow Optimization and Optimal Power Flow, J. C. Das, CRC press, 2017, 1e
4. Power System Analysis, Operation and Control, Abhijit Chakrabarti and Suita Halder, PHI, 2010, 3rd Edition
5. Power System Operation, Robert H. Miller, James H. Malinowski, Tata McGraw Hill, 2009

Web links and Video Lectures (e-Resources):

Online Resources:

1. Website reference links: https://www.youtube.com/playlist?list=PL4BFB13CCDB954BCF
2. https://www.youtube.com/playlist?list=PL4BFB13CCDB954BCF
3. https://nptel.ac.in/courses/108/104/108104052/

Skill Development Activities Suggested

Course Outcomes:

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

CO1	Analyse the economic operation of Thermal and Hydro generating units
CO2	Apply conventional optimization techniques for evaluation of Unit Commitment problem
CO3	Evaluate Economic Load dispatch, Unit Commitment and Automatic Generation control problems
CO4	Specify strategies for effective planning of power system
CO5	Apply optimization techniques to solve optimal power flow problem.

Semester- III

SMART GRID TECHNOLOGY			
Course Code	22EPS324	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	

Course Learning objectives:

Module-1	
Introduction to Smart Grid: Introduction to Smart Grid - 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.	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos
Module-2	
Smart Grid Architecture: Components and Architecture of Smart Grid Design – Review of the proposed architectures for Smart Grid. The fundamental components of Smart Grid designs – Transmission Automation – Distribution Automation – Renewable Integration **Tools and Techniques for Smart Grid:** Computational Techniques – Static and Dynamic Optimization Techniques – Computational Intelligence Techniques – Evolutionary Algorithms – Artificial Intelligence techniques	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos
Module-3	
Distribution Generation Technologies: Introduction to Renewable Energy Technologies – Micro grids – Storage Technologies –Electric Vehicles and plug – in hybrids – Environmental impact and Climate Change – Economic Issues.	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos
Module-4	
Communication Technologies and Smart Grid: 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	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos
Module-5	
Control of Smart Power Grid System: Load Frequency Control (LFC) in Micro Grid System – Voltage Control in Micro Grid System – Reactive Power Control in Smart Grid. Case Studies and Test beds for the Smart Grids.	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

1. Smart Grids, Infrastructure, Technology and Solutions, Stuart Borlase, CRC Press, 2013, 1st Edition.
2. Renewable and Efficient Electric Power System, Gil Masters, Wiley–IEEE Press, 2013, 2nd Edition.
3. Synchronized Phasor Measurements and their Applications, A.G. Phadke and J.S. Thorp, Springer Edition, 2017, 2nd Edition.
4. Wind Power in Power Systems, T. Ackermann, Hoboken, NJ, USA, John Wiley, 2012, 2nd Edition.

Web links and Video Lectures (e-Resources):

https://archive.nptel.ac.in/noc/courses/noc18/SEM2/noc18-ee42/
https://archive.nptel.ac.in/noc/courses/noc18/SEM2/noc18-ee42/
https://scholar.google.co.in/scholar?q=SMART+GRID+TECHNOLOGY%09swayam&hl=en&as_sdt=0&as_vis=1&oi=scholart

Skill Development Activities Suggested

Course Outcomes:

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

CO1	Understand the various aspects of the smart grid and its development.
CO2	Understand grid architecture design, various performance analysis tools for smart grid design.
CO3	Analyse micro grids and distributed generation systems.
CO4	Identify suitable communication networks for smart grid application
CO5	Prepare test bed and carryout various analysis on Smart grid.

Semester- III

DISTRIBUTED GENERATION AND MICRO GRID.

Course Code	**22EPS325**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	**03**	Exam Hours	03

Course Learning objectives:

Module-1

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

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-2

DISTRIBUTED GENERATIONS (DG)

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

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-3

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

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-4

MICROGRIDS: Concept and definition of micro grid, micro grid drivers and benefits, review of sources of micro grids, typical structure and configuration of a micro grid, AC and DC micro grids, Power Electronics interfaces in DC and AC micro grids, communication infrastructure, modes of operation and control of micro grid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes:

passive, active and communication based techniques.	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-5

POWER QUALITY ISSUES IN MICROGRIDS: Power quality issues in micro grids- Modelling and Stability analysis of Micro grid, regulatory standards, Micro grid economics, Introduction to smart micro grids.

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**
3. to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:Books

1. Voltage Source Converters in Power Systems: Modeling, Control and
2. Applications, Amirnaser,Yezdani, and Reza Iravani, IEEE John Wiley Publications,2009.
3. Power Switching Converters: Medium and High Power, Dorin Neacsu, CRC Press, Taylor & Francis, 2006.
4. Solar Photo Voltaics, Chetan Singh Solanki, PHI learning Pvt. Ltd., New Delhi,2009.
5. Wind Energy Explained, theory design and applications,J.F. Manwell, J.G. McGowan Wiley publication,2002.
6. Biomass Regenerable Energy,D. D. Hall and R. P. Grover, John Wiley, New York, 1987.
7. Renewable Energy Resources, John Twidell and Tony Weir, Tyalor and Francis Publications, 2005

Web links and Video Lectures (e-Resources):

https://onlinecourses.nptel.ac.in/noc20_ee84/preview
https://onlinecourses.nptel.ac.in/noc19_ee63/preview
https://onlinecourses.nptel.ac.in/noc22_ee82/preview

Skill Development Activities Suggested

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Course Outcomes:

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

CO1	Understand exploration of renewable energy sources
CO2	Understand philosophy of distributed generation
CO3	Understand various issues of DG with grid integration
CO4	Understand the concept of micro grid, control and protection issues of micro grid.
CO5	Model and analyse the micro grid, understand various power quality issues.

Semester-III-------Professional Elective-4

Smart Appliances and Internet of Things			
Course Code	22EPS331	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

Module-1	
Modern Domestic Appliances Solid State Lamps: Introduction - Review of Light sources - white light generation techniques- Characterization of LEDs for illumination application. Power LEDs- High brightness LEDs- Electrical and optical properties.	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-2	
LED driver considerations-Power management topologies - colour issues of white LEDs- Dimming of LED sources, BLDC motors for pumping and domestic fan appliances, inverter technology-based home appliances, Smart devices and equipment.	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-3	
IoT Communication Technologies Introduction to IoT, Sensing, Actuation, Basics of Networking, Communication Protocols, Sensor Networks, Machine-to-Machine Communications. Interoperability in IoT.	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-4	
IoT Control Technologies and Programming Introduction to Arduino Programming, Integration of Sensors and Actuators with Arduino, Internet of Things Open-Source Systems. Introduction to Python programming, Introduction to Raspberry. Implementation of IoT with Raspberry Pi, Smart Grid Hardware Security.	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-5	
IoT Cloud Computation and Applications Introduction to SDN. SDN for IoT, Data Handling and Analytics, Cloud Computing, Sensor-Cloud. Fog Computing, Smart Cities and Smart Homes, Electric Vehicles, Industrial IoT, Case Study: Agriculture, Healthcare, Activity Monitoring, Role of ML and AI in IoT.	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of 20 Marks
2. Two assignments each of 20 Marks or one Skill Development Activity of 40 marks
   to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be scaled down to 50 marks

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books:

1. Fundamentals of Solid-State Lighting, Vinod Kumar Khanna, CRC press, 2014, 1st Edition.
2. Permanent Magnet Brushless DC Motor Drives and Controls, Chang-liang Xia, John Wiley & Sons Singapore Pte. Ltd., 2012, 1st Edition.
3. IoT for Smart Grids Design Challenges and Paradigms, K. Siozios, D. Anagnostos, D. Soudris, E. Kosmatopoulos, Springer, 2019, 1st Edition.
4. Advanced Lighting Controls: Energy Saving Productivity, Technology & Applications, Craig Di Louie, Fairmont Press, Inc., 2006, 1st Edition.
5. Lighting Control: Technology and Applications, Robert S Simpson, Focal Press, 2003, 1st Edition.
6. Introduction to solid state lighting, Arturas Zukauskus, Michael S. Shur & Remis Gaska, Wiley- Interscience, 2002, 1st Edition.
7. Power Electronics: Converters, Applications and Design, Mohan, Undeland and Robbins, John Wiley and Sons, 1989, 1st Edition.

Web links and Video Lectures (e-Resources):

1. www.aboutlightingcontrols.org.
2. www.ti.com
3. https://onlinecourses.nptel.ac.in/noc22_cs53/preview
4. https://nptel.ac.in/courses/108108098
5. https://elearn.nptel.ac.in/shop/iit-workshops/completed/location-tracking-for-internet-of-things/
6. https://onlinecourses.nptel.ac.in/noc21_ee85/preview

Skill Development Activities Suggested

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Course Outcomes:

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

CO1	Understand and evaluate the characteristics of smart home appliances.
CO2	Understand the behaviour of IoT and their applications
CO3	Manage smart communication systems with multiple sensors and protocols
CO4	Design and simulate smart homes and smart cities with IoTs and cloud computing
CO5	Compare IOT Applications in Industries & real-world.

Semester-III

SOFT COMPUTING TECHNIQUES AND ITS APPLICATIONS			
Course Code	**22EPS332**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	**3:0:0**	SEE Marks	50
Total Hours of Pedagogy	**40**	Total Marks	100
Credits	**03**	Exam Hours	

Course Learning objectives:

Module-1	
Introduction to Soft Computing: Concept of computing systems, soft vs. hard computing, various types of soft computing techniques, Fuzzy Computing, Neural Computing, Genetic Algorithms, Adaptive Resonance Theory, Classification, Some applications of soft computing techniques.	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos
Module-2	
Fuzzy Set Theory: Operations on fuzzy sets, properties of standard operations, T norm and S norm, Extension principle and application. Height of fuzzy set, core of fuzzy set, support of fuzzy set, normal fuzzy set, normalization of fuzzy set, level set, α cut and strong α cut of fuzzy set, concentration and dilation of fuzzy sets, fuzzy singleton, crossover points.	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos
Module-3	
Fuzzy relation: fundamentals of fuzzy relations, operations on fuzzy relations, composition of fuzzy relations, fuzzy reasoning, fuzzy relation inferences, compositional rule of inference, fuzzification. Fuzzy methods in control theory: Introduction to fuzzy logic controller, types of fuzzy logic controllers, basic structure of fuzzy knowledge based controllers, de-fuzzification methods, applications of fuzzy logic control.	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos
Module-4	
Introduction to artificial neural networks, artificial neuron model, and types of activation functions. Learning in neural networks, feed forward and feedback neural networks, back propagation training algorithm, Hopfield network, Boltzmann machine. Self-organizing map, learning vector quantization algorithm	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos
Module-5	
Evolutionary Algorithm: Fundamentals of Genetic Algorithms, basic concepts of "Genetics" and "Evolution", working principle, encoding, and fitness function, reproduction, genetic Modeling. Basic GA framework and different GA architectures, GA operators: Crossover, Selection, Mutation, Solving single-objective optimization problems using GAs.	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

1. Klir, G.J. & Yuan,B.- Fuzzy sets and Fuzzy logic, theory and applications, Prentice Hall of India Private Limited.
2. M. Ganesh - Introduction to fuzzy sets and fuzzy logic, PHI.
3. N. P. Padhy – Artificial intelligence and intelligent systems, Oxford.
4. Timothy J. Ross – Fuzzy logic with engineering applications, Wiley.
5. Nie and Linkens,- Fuzzy Neural Control-Principles, Algorithms and Application, PHI
6. J.S.R. Jang, C.T. Sun, E. Mizutani - Neuro-fuzzy and soft computing, PHI.
7. Neural Network Design, Martin T. Hagan, Howard B. Demuth, Mark H. Beale, PWS Publishing, 1999.
8. S.N. Shivnandam, "Principle of soft computing", Wiley India.
9. S.Rajasekaran, G.A.VijayalakshmiPai, "Neural Networks, Fuzzy Logic and Genetic Algorithms synthesis and applications ", PHI, 2003

Web links and Video Lectures (e-Resources):

https://onlinecourses.nptel.ac.in/noc22_cs54/preview#:~:text=It%20has%20enormous%20applications%20in,interdisciplinary%20nature%20and%20students%20from
https://archive.nptel.ac.in/courses/106/105/106105173/
https://archive.nptel.ac.in/noc/courses/noc19/SEM1/noc19-cs23/
https://nptel.ac.in/courses/127105006

Skill Development Activities Suggested

Course Outcomes:

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

CO1	Explain how intelligent system works
CO2	Apply basics of Fuzzy logic and neural networks
CO3	Discuss the ideas of fuzzy sets, fuzzy logic and use of heuristics based on human experience
CO4	Relate with neural networks that can learn from available examples and generalize to form appropriate rules for inference systems
CO5	Describe with genetic algorithms and other random search procedures useful while seeking global optimum in self-learning situations

Semester-III

NUMERICAL TECHNIQUES IN ELECTROMAGNETICS			
Course Code	22EPS333	CIE MARKS	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE MARKS	50
Total Hours of Pedagogy	40	TOTAL MARKS	100
Credits	03	EXAM HOURS	03

Course Learning objectives:

Module-1	
Review of vector calculus, electromagnetic fields, and an overview of computational electromagnetics Numerical integration, Introduction to integral equations, and the Helmholtz equation	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos
Module-2	
Surface integral equations in 2D, Green's functions, Solving surface integral equations by method of moments	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos
Module-3	
Solving volume integral equations by method of moments, Introduction to finite element methods Finite element method in 1D	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos
Module-4	
Finite element method in 2D, Finite difference time domain method – introduction, Finite difference time domain method - materials and boundary conditions	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos
Module-5	
Finite difference time domain method - perfectly matched layers, Applications of CEM -- inverse problems and antenna radiation problems, Applications of CEM -- antenna radiation problems and hybrid methods	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:Books

1. W. L. Stutzman and G. A. Thiele, Antenna Theory and Design, Second Edition, John Wiley & Sons, NY, 1998.
2. Computational Methods for Electromagnetics - Peterson, Ray, Mitra, IEEE Press
3. Advanced Engineering Electromagnetics - C A Balanis, Wiley India.
4. Waves and fields in inhomogeneous media - W C Chew, IEEE Press
5. Finite Element Method for Electromagnetics: Antennas, Microwave Circuits, and Scattering Applications - Volakis, Chatterjee, and Kempel, Wiley

Web links and Video Lectures (e-Resources):

https://nptel.ac.in/courses/108104099
https://onlinecourses.nptel.ac.in/noc21_ee82/preview
https://archive.nptel.ac.in/course.html
https://archive.nptel.ac.in/courses/108/101/108101090/
file:///C:/Users/User/OneDrive/Desktop/APPLIED%20ELECTROMAGNETICS%20FOR%20ENGINEERS.pdf
https://onlinecourses.nptel.ac.in/noc21_ee91/preview

Skill Development Activities Suggested

Course Outcomes:

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

CO1	Understand the fundamentals of electromagnetic system.
CO2	Carryout electromagnetic analysis in 2dimensional plane.
CO3	Understand the basic concepts of different numerical techniques.
CO4	Carryout field analysis in 1D and 2D by using different numerical methods.
CO5	Carryout antenna radiation problems and hybrid methods using CEM

Semester-III

ENERGY AUDITING AND MANAGEMENT

Course Code	**22EPS334**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	**3:0:0**	SEE Marks	50
Total Hours of Pedagogy	**40**	Total Marks	100
Credits	**03**	Exam Hours	

Course Learning objectives:

Module-1

Energy Audit And Demand Side Management (DSM) in Power Utilities
Energy Scenario & Conservation -Demand Forecasting Techniques- Integrated Optimal Strategy for Reduction of T&D Losses - DSM Techniques and Methodologies- Loss Reduction in Primary and Secondary Distribution system and capacitors - Energy Management – Role of Energy Managers - Energy Audit – Metering

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-2

Energy Audit :Energy audit concepts, Basic elements and measurements, Mass and energy balances, Scope of energy auditing in industries

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-3

Energy Audit of Electrical Equipment- Evaluation of energy conservation opportunities and environmental management- Preparation and presentation of energy audit reports, case studies for Induction motors, Transformers, Cables, Lighting, AC systems, Pumps, Capacitor banks and potential energy savings

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-4

Instrumentation: Evaluation and instrumentation techniques for renewable energy systems (solar thermal, photovoltaic and wind energy); energy management devices; micro controller based systems	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-5

Energy Conservation: Energy conservation in HVAC systems and thermal power plants, Solar systems, Fan and Lighting Systems - Different light sources and luminous efficacy, Energy conservation in electrical devices and systems, Economic evaluation of energy conservation measures, Electric motors and transformers, Inverters and UPS, Voltages stabilizers	
Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**
   to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Energy Engineering and management, Amlan Chakrabarti, PHI, 2018
2. Energy auditing in Electrical utilities, Rajiv Shanker, Viva books Pvt.Ltd., 2015
3. Industrial energy management and utilization, Larry C. Witte, Schmidt & Brown, Hemisphere publishing Co., New York, 1988
4. Energy management handbook, Wayne. C Turner, Wiley Inter-science publications, New York, 1982
5. Analysis and Design of Energy Systems, Hodge B.K, Prentice Hall, 2002

Web links and Video Lectures (e-Resources):

1. NPTEL :: Electrical Engineering - Energy Management Systems and SCADA
2. https://nptel.ac.in/courses/108106022
3. https://iare.ac.in/sites/default/files/iare_EAM_lecture%20notes.pdf
4. https://beeindia.gov.in/sites/default/files/1Ch3.pdf
5. https://iopelonere.com/nslingayat/

Skill Development Activities Suggested

Course Outcomes:

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

CO1	Understand the energy demand, loss and conservation of energy. Understand the use of various energy metering tools in energy management.
CO2	Understand the principles of energy audit and energy management.

CO3	Identify and describe the basic principles and methodologies adopted in energy audit of utility. Prepare energy audit report for various electrical equipments.
CO4	Describe the energy performance evaluation of some common electrical and thermal installations and identify the energy saving opportunities.
CO5	Recommend energy efficient motors and design good lighting system.

SEMESTER- III

MODELLING AND SIMULATION OF POWER ELECTRONICS SYSTEM.			
Course Code	**22EPS335**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	**3:0:0**	SEE Marks	50
Total Hours of Pedagogy	**40**	Total Marks	100
Credits	**03**	Exam Hours	

Course Learning objectives:

Module-1

Introduction: Challenges in computer simulation - Simulation process - mechanics of simulation - Solution Techniques for time domain analysis - Equation solvers - circuit-oriented simulators. Simulation of Power Electronic Converters: State-space representation of power electronic converters (with buck converter as a representative example) - Trapezoidal integration - M & N method for simulating power electronic converters (with buck converter as a representative example) - Introduction to MATLAB and Simulink - Simulation of rectifiers - choppers and inverter circuits along with PWM techniques

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-2

Simulation of Electric Drives: Modeling of power electronic converters with transportation delay - Concept of control gain - linearization of rectifiers with inverse cosine control - State space model of 3-Ph IM – Principle of Vector control - Modeling and simulation of Vector controlled 3-Ph IM with a 3-level inverter drive

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-3

Modeling - Simulation of Switching Converters with State Space Averaging: State Space Averaging Technique- Modeling AND linearization of converter transfer functions -Simulation and Design of power electronic converters using State-space averaged models

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-4

Modeling and simulation of impedance based compensators Modeling and analysis of series and shunt static Var Compensators

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Module-5

Modeling and simulation of converter based compensators. Modeling and Analysis of STATCOM, SSSC, UPFC.

Teaching-Learning Process	Chalk and talk, Power point presentation, Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:Books

1. Simulation of Power Electronic Converters, M. B. Patil - V. Ramnarayanan, V. T.Ranganathan ,1st ed., Narosa Publishers, 2010
2. Power Electronics: Converters, Design and control, Ned Mohan, Undeland and Robbins, - 2nd ed., John Wiley
3. Power Electronics Step-by-Step Design, Modeling, Simulation, and Control Weidong Xiao University of Sydney New York Chicago SanFrancisco Athens London Madrid Mexico City Milan NewDelhi Singapore Sydney Toronto
4. Modelling and Simulation of Power Electronic Converter Dominated Power Systems in Power Factory Hardcover – Import, 3 November 2020 by Francisco M. Gonzalez-Longatt (Editor), José Luis Rueda Torres (Editor), Publisher : Springer; 1st ed. 2021 edition (3 November 2020)

Web links and Video Lectures (e-Resources):

- https://onlinecourses.nptel.ac.in/noc20_ee12/preview
- https://nptel.ac.in/courses/108105186
- https://onlinecourses.nptel.ac.in/noc21_ee01/preview
- https://onlinecourses.nptel.ac.in/noc22_ee33/preview
- https://archive.nptel.ac.in/noc/courses/noc20/SEM1/noc20-ee12/
- https://alison.com/course/engineering-system-design-modeling-techniques

Skill Development Activities Suggested

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Course Outcomes:

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

CO1	Understand and apply computer simulation process, challenges and techniques modeling and simulation of power electronics converters.
CO2	Apply the state space modelling techniques for simulation of power electronics converters
CO3	Use the SIMULINK tool for simulation of various power electronics converters
CO4	Model and simulate the electrical drives and analyse the performance.
CO5	Apply state space averaging technique to model power electronics converters CO6 Model and simulate the FACT controllers.