# Francis Xavier Engineering College

(An Autonomous Institution)
Tirunelveli 627 003
Tamil Nadu India

# Department of EEE

## M. E - Power Systems Engineering

### 2021 CURRICULUM AND SYLLABI

### CHOICE BASED CREDIT SYSTEM

### Regulations 2019

**Vision of the Department**

**"To be a Centre of Excellence for Technology transformation in the field of Electrical and Electronics Engineering"**

Mission of the Department

1. **To empower the vibrant young leaders with technical skills and knowledge in the field of technology**
2. **To facilitate the industries to adopt effective solutions in the field of Electrical and Electronics Engineering through consultancy**
3. **To transform technology for rural needs.**

# Table of Content

# Programme Educational Outcomes (PEOs)

PEO1: **To produce electrical Power Systems post graduates, who are employable in public and private industries/ Institutes/Organization, or pursue higher education.**

PEO2: **To prepare graduates who have the ability to identify and address current and future problems in the domain of power systems, power electronics and drives.**

PEO3: **To inculcate research attitude and lifelong learning among graduates**

# Programme Specific Objectives (PSOs)

PSO 1: Integrate the knowledge of, power Systems and Switch gears for the controllability, reliability and sustainability of electrical systems.

PSO2: Contribute for the development of power grid and integrating green energy on it to meet the increasing demand of the society.

# Programme Outcomes (POs)

**Engineering Graduates will be able to:**

1. Graduates will be able to demonstrate the principles and practices of the electrical power industry regarding generation, transmission, distribution and electrical machines and their controls.
2. Graduates will be able to apply their knowledge of electrical power principles, as well as mathematics and scientific principles, to new applications in electrical power.
3. Graduates will be able to perform, analyze, and apply the results of experiments to electrical power application improvements.
4. Graduates will be able to look at all options in design and development projects and creativity and choose the most appropriate option for the current project.
5. Graduates will function effectively as a member of a project team.
6. Graduates will be able to identify problems in electrical power systems, analyze the problems, and solve them using all of the required and available resources.
7. Graduates will be able to effectively communicate technical project information in writing or in personal presentation and conversation.
8. Graduates will be engaged in continuously learning the new practices, principles, and techniques of the electrical power industry.
9. Graduates will work on application software packages for power system analysis and design.
10. Graduates will develop indigenous software packages for power system planning and operational problems of utilities.

Mapping with PO Vs PEO, PSO

| PO | PEO1 | PEO2 | PEO3 | PSO1 | PSO2 |
|---|---|---|---|---|---|
| 1 | X | | | X | |
| 2 | | X | | | X |
| 3 | | | X | X | |
| 4 | | X | | X | |
| 5 | X | | | | X |
| 6 | | X | | X | |
| 7 | X | | | | X |
| 8 | | | X | X | |
| 9 | | X | | | X |
| 10 | X | | | | X |

**FRANCIS XAVIER ENGINEERING COLLEGE**

**M.E. – POWER SYSTEMS ENGINEERING REGULATIONS 2019**

**Choice Based Credit System and Outcome Based Education**

**SUMMARY OF CREDIT DISTRIBUTION**

| S.No | Category | Credit Distribution | | | | Total Credits | Credits in % |
|---|---|---|---|---|---|---|---|
| | | I | II | III | IV | | |
| 1 | HSSM | | | | | | |
| 2 | BS | 4 | | | | 4 | 5.4 |
| 3 | EC | | | | | | |
| 4 | PC | 16 | 15 | | | 31 | 42.4 |
| 5 | PE | 3 | 6 | 9 | | 18 | 24.6 |
| 6 | OE | | | | | | |
| 7 | EEC | | 2 | 6 | 12 | 20 | 27.3 |

**Minimum Number of Credits to be Acquired: 73**

HSS - Humanities and Social Sciences including Management

BS - Basic Science

ES - Engineering Sciences

PC - Professional Core

PE - Professional Elective

OE – Open Elective/Programme Specific Elective for Expandable Scope

EEC - Employability Enhancement Course

**FRANCIS XAVIER ENGINEERING COLLEGE**

**M.E. – POWER SYSTEMS ENGINEERING REGULATIONS 2021**

**Choice Based Credit System and Outcome Based Education**

**I-IV Semester Curricula and Syllabi**

**SEMESTER I**

| S.No | Course Code | Course Name | Category | Contact Periods | L | T | P | C |
|---|---|---|---|---|---|---|---|---|
| **Theory Courses** | | | | | | | | |
| 1 | 21MA1253 | Advanced Engineering Mathematics | BS | 4 | 3 | 1 | 0 | 4 |
| 2 | 21PS1601 | Advanced Power System Modeling and Analysis | PC | 3 | 3 | 0 | 0 | 4 |
| 3 | 21PS1602 | State Estimation and Security Control of Power Systems | PC | 4 | 3 | 1 | 0 | 3 |
| 4 | 21PS1603 | Power System Operation and Control | PC | 3 | 3 | 0 | 0 | 3 |
| 5 | 21PE1604 | Power Quality Analysis and Mitigation Techniques | PC | 4 | 3 | 1 | 0 | 4 |
| 6 | | Professional Elective I | PE | 3 | 3 | 0 | 0 | 3 |
| **Practical Courses** | | | | | | | | |
| 1 | 21PS1611 | Power System Simulation Laboratory | PC | 4 | 0 | 0 | 4 | 2 |
| | | | **Total** | 25 | 18 | 3 | 4 | **23** |

**SEMESTER II**

| S.No | Course Code | Course Name | Category | Contact Periods | L | T | P | C |
|---|---|---|---|---|---|---|---|---|
| **Theory Courses** | | | | | | | | |
| 1 | 21PS2601 | Digital Protection for Power System | PC | **3** | 3 | 0 | 0 | 3 |
| 2 | 21PS2602 | Power Systems Stability | PC | **3** | 3 | 1 | 0 | 4 |
| 3 | 21PS2603 | Restructured Power System | PC | **3** | 3 | 0 | 0 | 3 |
| 4 | 21PS2604 | Energy Management and Auditing | PC | **3** | 3 | 0 | 0 | 3 |
| 5 | | Professional Elective II | PE | **3** | 3 | 0 | 0 | 3 |
| 6 | | Professional Elective III | PE | **3** | 3 | 0 | 0 | 3 |
| **Practical Courses** | | | | | | | | |
| 1 | 21PS2611 | Advanced Power System Simulation Laboratory | PC | 4 | 0 | 0 | 4 | 2 |
| 2 | 21PS2911 | Innovative Project | EEC | 2 | 0 | 0 | 2 | 2 |
| | | | **Total** | 24 | **18** | **0** | **6** | **23** |

**SEMESTER III**

| S.No | Course Code | Course Name | Category | Contact Periods | L | T | P | C |
|---|---|---|---|---|---|---|---|---|
| **Theory Courses** | | | | | | | | |
| 1 | | Professional Elective IV | PE | **3** | 3 | 0 | 0 | 3 |
| 2 | | Professional Elective V | PE | **3** | 3 | 0 | 0 | 3 |
| 3 | | Professional Elective VI | PE | **3** | 3 | 0 | 0 | 3 |
| **Practical Courses** | | | | | | | | |
| 1 | | Project Work Phase I | EEC | 12 | 0 | 0 | 12 | 6 |
| | | | **Total** | 21 | **09** | **0** | **12** | **15** |

**SEMESTER IV**

| S.No | Course Code | Course Name | Category | Contact Periods | L | T | P | C |
|---|---|---|---|---|---|---|---|---|
| **Practical Courses** | | | | | | | | |
| 1 | | Project Work Phase II | EEC | 24 | 0 | 0 | 24 | 12 |
| | | | **Total** | 24 | 0 | 0 | 24 | 12 |

**Minimum Number of Credits to be Acquired: 73**

## List of Professional Electives Courses

| S.No | Course Code | Course Name | Semester | L | T | P | C | Stream/Domain |
|---|---|---|---|---|---|---|---|---|
| **Professional Elective I** | | | | | | | | |
| 1 | 21PS1701 | Power Distribution System Reliability | I | 3 | 0 | 0 | 3 | Electrical machines |
| 2 | 21PE1601 | Analysis and Design of Power Electronic Converters | I | 3 | 0 | 0 | 3 | Power Electronics |
| 3 | 21PS1702 | Electrical Distribution System | I | 3 | 0 | 0 | 3 | Power Systems |
| 4 | 21PS1703 | Computer Aided Power System analysis | I | 3 | 0 | 0 | 3 | Power Systems |
| **Professional Elective II** | | | | | | | | |
| 1 | 21PS2701 | Principles of Smart Grid | II | 3 | 0 | 0 | 3 | Power Systems |
| 2 | 21PE2601 | Generalized Machine Theory | II | 3 | 0 | 0 | 3 | Control Systems |
| 3 | 21PE2603 | Modern Control Theory | II | 3 | 0 | 0 | 3 | Power Systems |
| 4 | 21PS2702 | Flexible AC Transmission Systems | II | 3 | 0 | 0 | 3 | Power Systems |
| **Professional Elective III** | | | | | | | | |
| 1 | 21PS2703 | Distributed Generation and Microgrid | II | 3 | 0 | 0 | 3 | Power Systems |
| 2 | 21PE2706 | Electromagnetic Interference and Compatibility | II | 3 | 0 | 0 | 3 | Field Theory |
| 3 | 21PE2709 | Embedded System Design | II | 3 | 0 | 0 | 3 | Embedded System |
| 4 | 21PE2705 | Modern Rectifiers and Resonant Converters | II | 3 | 0 | 0 | 3 | Power Electronics |
| **Professional Elective IV** | | | | | | | | |
| 1 | 21PE3706 | Integrated Circuits for Power Conversion | III | 3 | 0 | 0 | 3 | Power Electronics |
| 2 | 21PS3701 | High Voltage Direct Current Transmission | III | 3 | 0 | 0 | 3 | Power Systems |
| 3 | 21PS3702 | SCADA | III | 3 | 0 | 0 | 3 | Power Systems |
| 4 | 21PE3702 | Wind Energy Technologies | III | 3 | 0 | 0 | 3 | Renewable Energy |
| **Professional Elective V** | | | | | | | | |
| 1 | 21PS3703 | Electrical Transients in Power System | III | 3 | 0 | 0 | 3 | Power Systems |
| 2 | 21PE3704 | Hybrid Electric Vehicles | III | 3 | 0 | 0 | 3 | Electrical machines |
| 3 | 21PS3704 | Principles of Electric Power Transmission | III | 3 | 0 | 0 | 3 | Power Systems |
| 4 | 21PE3707 | MEMS Technology | III | 3 | 0 | 0 | 3 | Electrical |

| **Professional Elective VI** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | 21PS3705 | Advanced Power System Dynamics | III | 3 | 0 | 0 | 3 | Power Systems |
| 2 | 21PS3706 | Design of Substations | III | 3 | 0 | 0 | 3 | Power Systems |
| 3 | 21PE3708 | Power Electronics for Renewable Energy Systems | III | 3 | 0 | 0 | 3 | Renewable Energy |
| 4 | 21PS3707 | Power Plant Instrumentation and Control | III | 3 | 0 | 0 | 3 | Instrumentation |

**Semester I**

| Course Code 21MA1253 | ADVANCED ENGINEERING MATHEMATICS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 1 | 0 | 4 |

**Prerequisites for the course**

Engineering Mathematics

**Objectives**

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

| UNIT I | MATRIX THEORY | 12 |
|---|---|---|

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

| UNIT II | CALCULUS OF VARIATIONS | 12 |
|---|---|---|

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

| UNIT III | PROBABILITY AND RANDOM VARIABLES | 12 |
|---|---|---|

Probability–Axioms of probability–Conditional probability–Baye's theorem-Random variables-Probability function–Moments–Moment generating functions and their properties–Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions–Function of a random variable.

| UNIT IV | LINEAR PROGRAMMING | 12 |
|---|---|---|

Formulation–Graphical solution–Simplex method–Big M method-Two phase method-Transportation and Assignment models.

| UNIT V | FOURIER SERIES | 12 |
|---|---|---|

Fourier trigonometric series : Periodic function as power signals–Convergence of series–Even and odd function : Cosine and sine series–Non periodic function : Extension to other intervals-Power signals : Exponential Fourier series–Parseval's theorem and power spectrum–Eigen value problems and orthogonal functions–Regular Sturm-Liouville systems–Generalized Fourier series.

| | |
|---|---|
| **Total Periods** | **60** |

**Suggestive Assessment Methods**

| **Continuous Assessment Test (30 Marks)** | **Formative Assessment Test (10 Marks)** | **End Semester Exams (60 Marks)** |
|---|---|---|
| ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** | **1.ASSIGNMENT**<br>**2. ONLINE QUIZZES**<br>**3.PROBLEM-SOLVING ACTIVITIES** | ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** |

**Outcomes**

**Upon completion of the course, the students will be able to:**

**CO 1:** Apply various methods in matrix theory to solve system of linear equations.
**CO 2:** Maximizing and minimizing the functional that occur in electrical engineering discipline.
**CO 3:** Computation of probability and moments, standard distributions of discrete and continuous random variables and functions of a random variable.
**CO 4:** Could develop a fundamental understanding of linear programming models, able to develop a linear programming model from problem description, apply the simplex method for Solving linear programming problems.
**CO 5:** Fourier series analysis and its uses in representing the power signals

**Reference Books**

**books after 2015 need to be suggested**


1. Andrews L.C. and Phillips R.L., "Mathematical Techniques for Engineers and Scientists",Prentice Hall of India Pvt. Ltd., New Delhi, 2005.
2. Bronson, R. “Matrix Operation”, Schaum’s outline series, 2ndEdition, McGraw Hill, 2011.
3. Elsgolc, L. D. "Calculus of Variations", Dover Publications, New York, 2007.
4. Johnson, R.A., Miller, I and Freund J., "Miller and Freund’s Probability and Statistics forEngineers", Pearson Education, Asia, 8thEdition, 2015.
5. O'Neil, P.V., "Advanced Engineering Mathematics", Thomson Asia Pvt. Ltd., Singapore, 2003.
6. Taha, H.A., “Operations Research, An Introduction”,9thEdition, Pearson education, NewDelhi, 2016.


**Web Recourses**

1. **https://nptel.ac.in/courses/111102012/**

CO Vs PO Mapping and CO Vs PSO Mapping

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **3** | **3** | | | | | | | | **2** | | 3 |
| 2 | **3** | **3** | | | | | | | | **2** | 2 | |
| 3 | **3** | **3** | | | | | | | | **2** | | 3 |
| 4 | **3** | **3** | | | | | | | | **2** | 3 | |
| 5 | **3** | **3** | | | | | | | | **2** | | 2 |

| **Course Code 21PS1601** | **ADVANCED POWER SYSTEM MODELING AND ANALYSIS** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|
| | | **4** | **1** | **0** | **4** |

**Prerequisites for the course**

- Transmission and Distribution
- Power Plant Engineering
- High Voltage Engineering
- Power System Analysis

**Objectives**

1. To discuss different techniques dealing with sparse matrix for large scale power systems.
2. To explain different methods of power flow solutions.
3. To solve optimal power flow problem.
4. To analyze various types of short circuit faults analysis and understand the consequence of different type of faults.
5. To demonstrate different numeric al integration methods and factors influencing transient stability.

| **UNIT I** | **SPARSE MATRIX TECHNIQUES** | **12** |
|---|---|---|

Optimal ordering schemes for preserving sparsity. Flexible packed storage scheme for storing matrix as compact arrays – Factorization by Bifactorization and Gauss elimination methods; Repeat solution using Left and Right factors and L and U matrices.

| **UNIT II** | **INCIDENCE AND MATRICES** | **12** |
|---|---|---|

Introduction – graphs – incidence matrices formation - YBus, YBR and Zloop by singular transformation, single phase modeling of transmission lines, off-nominal transformer tap representation and phase shift representation - formation of Ybus with direct inspection method.

| **UNIT III** | **POWER FLOW ANALYSIS** | **12** |
|---|---|---|

Power Flow Analysis: Formulation of power flow problem – solution through Gauss-Seidel method, Newton Raphson method - decoupled and fast decoupled power flow solutions - DC power flow solution – comparison of GS – NR – FDC method. Study of Power flow solution with FACTS devices - Renewable Energy Sources –Solar and Wind Energy Sources.

| **UNIT IV** | **CONTINGENCY ANALYSIS** | **12** |
|---|---|---|

Adding and removing multiple lines, piece wise solution of interconnected systems, analysis of single and multiple contingencies, Contingency analysis by DC Model.

| **UNIT V** | **TRANSIENT STABILITY ANALYSIS** | **12** |
|---|---|---|

Introduction, Numerical Integration Methods: Euler and Fourth Order Runge-Kutta methods, Algorithm for simulation of SMIB and multi-machine system with classical synchronous machine model; Factors influencing transient stability, Numerical stability and implicit Integration methods.

| | **Total Periods** | **45+15** |
|---|---|---|

**Suggestive Assessment Methods**

| **Continuous Assessment Test (30 Marks)** | **Formative Assessment Test (10 Marks)** | **End Semester Exams (60 Marks)** |
|---|---|---|
| ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** | **1.ASSIGNMENT**<br>**2. ONLINE QUIZZES**<br>**3.PROBLEM-SOLVING ACTIVITIES** | ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** |

**Outcomes**

**Upon completion of the course, the students will be able to:**

**CO 1:** Ability to apply the concepts of sparse matrix for large scale power system analysis.

**CO 2:** Ability to analyze power system studies that needed for the transmission system planning.

**CO 3:** Able to solve optimal power flow problems.

**CO 4:** Able to analyse short circuit faults and understand the consequence faults.

**CO 5:** Ability to understand AI integration methods and factors influencing transient stability.

**Text Books**

1. B.W Williams 'Power Electronics Circuit Devices and Applications'..
2. A.J.Wood and B.F.Wollenberg, "Power Generation Operation and Control", John Wiley and sons, New York, 1996.
3. W.F.Tinney and W.S.Meyer, "Solution of Large Sparse System by Ordered Triangular Factorization" IEEE Trans. on Automatic Control, Vol : AC-18, pp:333- 346, Aug 1973.
4. K.Zollenkopf, "Bi-Factorization: Basic Computational Algorithm and Programming Techniques; pp:75-96 ; Book on "Large Sparse Set of Linear Systems" Editor: J.K.Rerd,Academic Press, 1971.
5. M.A.Pai," Computer Techniques in Power System Analysis",Tata McGraw-Hill Publishing Company Limited, New Delhi, 2006.
6. G W Stagg , A.H El. Abiad, "Computer Methods in Power System Analysis", McGraw Hill, 1968.
7. P.Kundur, "Power System Stability and Control", McGraw Hill, 1994.

**Web Recourses**

- https://presentgroup.com.au/power-system-modelling-and-analysis/
- https://www.osti.gov/servlets/purl/1083672
- https://link.springer.com/chapter/10.1007/978-3-319-02393-9_2
- http://www.optimisedenergysolutions.com/services-modellingandanalysis.aspx
- https://www.engineersaustralia.org.au/Event/power-system-modelling-and-analysis-presentation

CO Vs PO Mapping and CO Vs PSO Mapping

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3 | | 2 | | | | | 3 | | 2 | | |
| 2 | 3 | | 2 | | | | | 3 | | 2 | 3 | |
| 3 | | 2 | 2 | | | 3 | | 3 | | 2 | | 3 |
| 4 | 3 | | | 3 | | 3 | | 3 | | 2 | 2 | |
| 5 | | 3 | | 3 | | 3 | | 3 | | 2 | | 3 |

| Course Code 21PS1602 | STATE ESTIMATION AND SECURITY CONTROL OF POWER SYSTEMS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Prerequisites for the course**

- Power System Analysis
- Power System operation and control
- Power Generation and Distribution

**Objectives**

1. To acquire fundamental knowledge in power system state estimation
2. To explore the strategies for state estimation in power system operations.
3. To perform observability analysis in the power system networks
4. To gain knowledge in distribution system state estimation
5. To get conceptual aspects in power system state estimation and strategies to enhance the secure power system operations.

| UNIT I | INTRODUCTION | 9 |
|---|---|---|

State estimation- Energy management system- SCADA system- Energy control centers Security monitoring and control- Concepts of reliability, security and stability - State transitions and control strategies- Data acquisition systems - Modulation techniques, MODEMS, Power line carrier communication.

| UNIT II | POWER SYSTEM STATE ESTIMATION | 9 |
|---|---|---|

Static state estimation: Active and reactive power bus measurements - Line flow measurements - Line current measurements – Bus voltage measurements - Measurement model and assumptions - Weighted least square state estimation algorithm- Maximum likelihood estimation - Decoupled formulation of WLS state estimation- Fast decoupled state estimation - State estimation using DC model of power system- Weighted least absolute value state estimation - Comparison of state estimation algorithms.

| UNIT III | NETWORK OBSERVABILITY ANALYSIS | 9 |
|---|---|---|

Tracking state estimation: Algorithm - Computational aspects - Measurement redundancy - Accuracy and variance of measurements - Variance of measurement residuals- Detection, identification and suppression of bad measurements – Kalman filtering approach Computational aspects - Approximations to reduce computations - Pseudo measurements Virtual measurements- External system equivalencing- Network observability – Observability analysis using phasor measurement units.

| **UNIT IV** | **DISTRIBUTION SYSTEM STATE ESTIMATION** | **9** |
|---|---|---|

Distribution system state estimation- State of the art methods – Comparison of different DSSE algorithms- Developments in measurement system and DSSE design- Pseudo measurements- System architecture.

| **UNIT V** | **SECURITY ASSESSMENT AND SECURITY ENHANCEMENT** | **9** |
|---|---|---|

Contingency analysis: Linearized AC and DC models of power systems for security assessment - Line outage distribution factors and generation shift factors for DC and linearized AC models - Single contingency analysis using these factors - Double line outage analysis techniques using bus impedance matrix and factors of bus admittance matrix- Fast contingency algorithms for nonlinear A.C. models.

| | |
|---|---|
| **Total Periods** | **45** |

**Suggestive Assessment Methods**

| **Continuous Assessment Test (30 Marks)** | **Formative Assessment Test (10 Marks)** | **End Semester Exams (60 Marks)** |
|---|---|---|
| ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** | **1.ASSIGNMENT**<br>**2. ONLINE QUIZZES**<br>**3.PROBLEM-SOLVING ACTIVITIES** | ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** |

**Outcomes**

**Upon completion of the course, the students will be able to:**

**CO 1:** Able to Understand the conceptual aspects in power system state estimation.

**CO 2:** Able to demonstrate various state estimation methods.

**CO 3:** Able to be proficient to perform observability analysis.

**CO 4:** Able to conduct distribution state estimation.

**CO 5:** Able to realize the security assessment and enhancement strategies.

**Text Books**

1. A.J. Wood, B.F. Wollenberg and G.B. Sheble, "Power Generation, Operation and Control", John Wiley and Sons, 3rd Edition, 2013.
2. Abhijit Chakrabarti and Sunita Halder, "Power System Analysis Operation and Control", PHI Learning, 2010.
3. K.Bhattacharya, M.H.J Bollen and J.E. Daaider, "Operation of restructured power system" Kluwer Power Electronics and Power System series (2001).

**REFERENCE BOOKS:**

1. Ali Abur, "Power System State Estimation Theory and Implementation", Marcel Dekker, 2004.
2. Sally Hunt, "Making competition work in Electricity", John Wiley, 2002
3. Mahalanabis, Kothari and Ahson, "Computer Aided Power System Analysis and Control", Tata McGraw Hill Publishers, 1991.
4. G.L. Kusic, "Computer Aided Power System Analysis", Prentice Hall of India, 1989.

**Web Recourses**

- **https://lecturenotes.in/m/36610-note-of-power-system-sequrity-by-mohit-katiyar**
- **https://overbye.engr.tamu.edu/course-2/ecen615fa2018/lecture-notes-ecen615_fa2018/**
- **https://nptel.ac.in/courses/108/101/108101040/**

| Course Code 21PS1603 | POWER SYSTEM OPERATION AND CONTROL | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Prerequisites for the course**

- Power system analysis
- Control system
- Power plant engineering

**Objectives**

1. To understand the fundamentals of speed governing system and the concept of control areas.
2. To provide knowledge about Hydro thermal scheduling, Unit commitment and solution techniques.
3. To impart knowledge on the need of state estimation and its role in the day- today operation of power system.

| UNIT I | INTRODUCTION | 9 |
|---|---|---|

System load variation: System load characteristics, load curves-daily, weekly and annual, load-duration curve, load factor, diversity factor. Reserver equirements: Installed reserves, spinning reserves, cold reserves, and hot reserves. Overview of system operation: Load forecasting, techniques of forecasting, basics of power system operation and control.

| UNIT II | REAL POWER- FREQUENCY CONTROL | 9 |
|---|---|---|

Fundamentals of speed governing mechanism and modeling :Speed-load characteristics– Load sharing between two synchronous machines in Parallel; concept of control area, LFC control of a single-area system: Static and dynamic analysis of uncontrolled and controlled cases, Economic Dispatch Control. Multi-area systems: Two-area system modelling; static analysis, uncontrolled case; tie line with frequency bias control of two-area system derivation.

| **UNIT III** | **HYDRO THERMAL SCHEDULING PROBLEM** | **9** |
|---|---|---|
| Hydrothermal scheduling problem: short term and long term-mathematical model, algorithm. Dynamic programming solution methodology for Hydro-thermal scheduling with pumped hydro plant: Optimization with pumped hydro plant- Scheduling of systems with pumped hydro plant during off-peak seasons: algorithm. Selection of initial feasible trajectory for pumped hydro plant-Pumped hydro plant as spinning reserve unit-generation of outage induced constraint. | | |
| **UNIT IV** | **UNIT COMMITMENT AND ECONOMIC DISPATCH** | **9** |
| Statement of Unit Commitment (UC) problem; constraints in UC: spinning reserve, thermal unit constraints, hydro constraints, fuel constraints and other constraints; UC solution methods: Priority-list methods, forward dynamic programming approach, numerical problems. Incremental cost curve, co-ordination equations without loss and with loss, solution by direct method and λ-iteration method. Base point and participation factors. Economic dispatch controller added to LFC control. | | |
| **UNIT V** | **STATE ESTIMATION** | **9** |
| Need for power system state estimation-Network observability –DC state estimation model-State estimation of power system–Methods of state estimation: Least square state estimation, Weighted least square state estimation, Maximum likelihood-Bad data detection and identification. | | |
| | **Total Periods** | **45** |

**Suggestive Assessment Methods**

| **Continuous Assessment Test (30 Marks)** | **Formative Assessment Test (10 Marks)** | **End Semester Exams (60 Marks)** |
|---|---|---|
| ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** | *1.**ASSIGNMENT***<br>***2. ONLINE QUIZZES***<br>***3.PROBLEM**-SOLVING ACTIVITIES* | ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** |

**Outcomes**

**Upon completion of the course, the students will be able to:**

**CO 1:** Learners will be able to understand system load variations and get an overview of power system operations.

**CO 2:** Learners will be exposed to power system state estimation.

**CO 3:** Learners will attain knowledge about hydrothermal scheduling.

**CO 4:** Learners will understand the significance of unit commitment and different solution methods.

**CO 5:** Learners will understand the need for state estimation in real time operation

**Reference Books**


1. Olle. I. Elgerd, "Electric Energy Systems Theory – An Introduction", Tata McGraw Hill Publishing Company Ltd, New Delhi, Second Edition, 2003.
2. D.P. Kothari and I.J. Nagrath, "Modern Power System Analysis", Third Edition, Tata McGraw Hill Publishing Company Limited, New Delhi, 2003.
3. L.L. Grigsby, "The Electric Power Engineering, Hand Book", CRC Press & IEEE Press,2001.
4. Allen.J.Wood and Bruce F.Wollenberg, "Power Generation, Operation and Control", John Wiley & Sons, Inc., 2003.
5. P. Kundur, "Power System Stability & Control", McGraw Hill Publications, USA, 1994.


**Web Recourses**

- https://nptel.ac.in/courses/108/101/108101040/

CO Vs PO Mapping and CO Vs PSO Mapping

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **2** | **2** | **2** | **1** | | | | **2** | **2** | **2** | 3 | |
| 2 | **2** | **2** | **1** | **1** | | | | **2** | **2** | **2** | | 3 |
| 3 | **2** | **2** | **1** | **1** | | | | **2** | **2** | **2** | | 3 |
| 4 | **2** | **2** | **1** | **1** | | | | **2** | **2** | **2** | | 3 |
| 5 | **2** | **2** | **1** | **1** | | | | **2** | **2** | **2** | 2 | |

| 21PE1604 | POWER QUALITY ANALYSIS AND MITIGATION TECHNIQUES | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 1 | 0 | 4 |

**Prerequisites for the course**

- Power Quality
- FACTS

**Objectives**

1. To impart knowledge on the Electrical power quality issues and power quality standards
2. To impart knowledge on the Analysis of various PQ issues
3. To impart knowledge on the power quality improvement.
4. To understand the conventional compensation techniques used for power factor correction and load voltage regulation.
5. To understand the active compensation techniques used for load voltage regulation.

| **UNIT I** | **POWER QUALITYAN OVERVIEW** | **12** |
|---|---|---|

Introduction – Characterization of Electric Power Quality: Transients, short duration and long duration voltage variations, Voltage imbalance, waveform distortion, Voltage fluctuations, Power frequency variation, Power acceptability curves – power quality problems: poor load power factor, Non-linear and unbalanced loads, DC offset in loads, Notching in load voltage, Disturbance in supply voltage – Power quality as per IEEE standard

| **UNIT II** | **ANALYSIS OF PQ ISSUES** | **12** |
|---|---|---|

Analysis of Harmonics distortion: Fourier series and Fourier Transform, Harmonic indices, Analysis of power outages, Analysis of voltage sag: Detorit Edison sag score, Voltage sag energy, Voltage Sag Lost Energy Index (VSLEI), Analysis of voltage flicker

| **UNIT III** | **POWER QUALITY IMPROVEMENT** | **12** |
|---|---|---|

Passive and active harmonic filters, phase multiplication, power conditioners, UPS, Constant voltage transformers, Introduction to custom power devices.

| **UNIT IV** | **DSTATCOM** | **12** |
|---|---|---|

Compensating single phase loads – Ideal three phase shunt compensator structure –Generating reference currents using instantaneous PQ theory – Instantaneous symmetrical components theory – Generating reference currents when the source is unbalanced – Realization and control of DSTATCOM – DSTATCOM in Voltage control mode.

| **UNIT V** | **DVR** | **12** |
|---|---|---|

Rectifier supported DVR – DC Capacitor supported DVR – DVR Structure – voltage Restoration – Series Active Filter. UPQC: Configurations and characteristics.

| | **Total Periods** | **60** |
|---|---|---|

**Suggestive Assessment Methods**

| **Continuous Assessment Test (30 Marks)** | **Continuous Assessment Test (30 Marks)** | **Continuous Assessment Test (30 Marks)** |
|---|---|---|
| ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** | **1.ASSIGNMENT**<br>**2. ONLINE QUIZZES**<br>**3.PROBLEM-SOLVING ACTIVITIES** | ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** |

**Outcomes**

**Upon completion of the course, the students will be able to:**

**CO 1**To understand various sources, causes and effects of power quality issues,electrical Systems and their measures and mitigation.

**CO 2** To Analyze the various PQ problems

**CO 3** Explain the conventional mitigation methods for PQ issues

**CO 4** To understand and design load compensation methods useful for mitigating power quality problems.

**CO 5** To acquire knowledge on DVR

**Text Books**

1. ArindamGhosh "Power Quality Enhancement Using Custom Power Devices", Kluwer Academic Publishers, 2002.
2. R.C. Duggan, Mark.F.McGranaghan,SuryaSantoas and H.WayneBeaty, Electrical Power System Quality", McGraw-Hill, 2017.
3. G.T.Heydt, "Electric Power Quality", Stars in a Circle Publications, 2002.
4. Bhim Singh, Ambrish Chandra, Kamal Al-Haddad , "Power Quality: Problems and Mitigation Techniques", John Wiley & Sons,2015.

**Reference Books**

1. Jos Arrillaga and Neville R. Watson ," Power system harmonics",Wiley,2015
2. Derek A. Paice , "Power Electronics Converter Harmonics :Multipulse Methods for Clean Power",Wiley,1999
3. Ewald Fuchs, Mohammad A. S. Masoum Power Quality in Power Systems and Electrical Machines,Elseveiracademic press publications,2016

CO Vs PO Mapping and CO Vs PSO Mapping

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 2 | 2 | | 1 | 3 | | | | 3 | 3 | |
| 2 | 2 | 2 | 2 | | 1 | 3 | | | | 3 | 3 | |
| 3 | 2 | | 2 | | 1 | 3 | | | | 3 | 3 | |
| 4 | 2 | | 2 | | 1 | 3 | | | | 3 | 3 | |
| 5 | 2 | 2 | 2 | | 1 | 3 | | | | 3 | 3 | |

| **Course Code 21PS1611** | **POWER SYSTEM SIMULATION LABORATORY** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|
| | | **0** | **0** | **4** | **2** |

**Prerequisites for the course**

- Power System Analysis

**Objectives**

1. To have hands on experience on various system studies and different techniques used for system planning using Software packages.
2. To perform the dynamic analysis of power system.

| S.No | List of Experiments |
|---|---|
| 1 | Power flow analysis by Newton-Raphson method and Fast decoupled method |
| 2 | Transient stability analysis of single machine-infinite bus system using classical machine model. |
| 3 | Contingency analysis: Generator shift factors and line outage distribution factors. |
| 4 | Economic dispatch using lambda-iteration method. |
| 5 | Unit commitment: Priority-list schemes and dynamic programming. |
| 6 | State Estimation (DC) |
| 7 | Analysis of switching surge using EMTP: Energization of a long distributed-parameter line. |
| 8 | Analysis of switching surge using EMTP: Computation of transient recovery voltage. |
| 9 | Simulation and Implementation of Voltage Source Inverter. |
| 10 | Digital Over Current Relay Setting and Relay Coordination using Suitable software packages. |
| 11 | Co-ordination of over-current and distance relays for radial line protection. |

**Total Periods :60**

**Suggestive Assessment Methods**

| | |
|---|---|
| **Lab Components Assessments (50 Marks)** | **End Semester Exams (50 Marks)** |
| **Viva Questions**<br>**Record and Observations** | **Viva-Voce**<br>**End Semester Exams** |

**Outcomes**

**Upon completion of the course, the students will be able to:**

**Laboratory Requirements**

**CO 1:** Analyze the power flow using Newton-Raphson method.

**CO 2:** Analyze the power flow Fast decoupled method

**CO 3:** Perform contingency analysis & economic dispatch.

**CO 4:** Understand the Set Digital Over Current Relay

**CO 5:** Understand Set Coordinate Relay

CO Vs PO Mapping and CO Vs PSO Mapping

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | | | 1 | | | | | | 2 | | 3 |
| 2 | 1 | | 2 | 2 | | | | | | 2 | 2 | |
| 3 | 2 | | | 2 | | | | | | 3 | | 2 |
| 4 | 2 | | | 3 | | | | | | 3 | 2 | |
| 5 | 3 | | | 3 | | | | | | 2 | | 3 |

| Course Code 21PS2601 | DIGITAL PROTECTION FOR POWER SYSTEM | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Prerequisites for the course**

- Power System Analysis
- Power System Operation and Control
- Protection and Switch Gear

**Objectives**

1. To illustrate concepts of transformer protection.
2. To describe about the various schemes of over current protection.
3. To analyzed instance and carrier protection.
4. To familiarize the concepts of Generator protection and Numerical protection.

| UNIT I | OVER CURRENT&EARTH FAULTPROTECTION | 9 |
|---|---|---|

Zones of protection– Primary and Backup protection– operating principles and Relay Construction- Time– Current characteristics- Current setting– Time setting- Over current protective schemes– Concept of Coordination- Protection of parallel /ring feeders- Reverse power or directional relay – Polarization Techniques – Cross Polarization–Quadrature Connection –Earth fault and phase fault protection - Combined Earth fault and phase fault

protection scheme- Phase fault protective-scheme directional earth fault relay –Static over current relays–Numerical over–current protection; numerical coordination example for a radial feeder.

| UNIT II | TRANSFORMER &BUSBAR PROTECTION | 9 |
|---|---|---|

Types of transformers–Types of faults in transformers- Types of Differential Protection–High Impedance–External fault with one CT saturation–Actual behaviors of a protective CT–Circuit model of a saturated CT-Need for high impedance–Disadvantages –Percentage Differential Bias Characteristics–Vector group & its impact on differential protection-Inrush phenomenon– Zero Sequence filtering–High resistance Ground Faults in Transformers–Restricted Earth fault Protection-Inter-turn faults in transformers–Incipient faults in transformers-Phenomenon of over fluxing in transformers– Transformer protection application chart. Differential protection of busbars external and internal fault-Supervisory relay-protection of three–Phase busbars–Numerical examples on design of high impedance busbar differential scheme–Biased Differential Characteristics– Comparison between Transformer differential &Busbar differential.

| UNIT III | DISTANCEAND CARRIER PROTECTION OFTRANSMISSION LINES | 9 |
|---|---|---|

Drawback of over–Current protection–Introduction to distance relay–Simple impedance relay–Reactance relay–mho relays comparison of distance relay–Distance protection of a three–Phase line-reasons for in accuracy of distance relay reach- Three stepped distance protection-Trip contact configuration for the three-Stepped distance protection-Three-stepped protection of three-phase line again stallten shunt faults-Impedance seen from relay side-Three-stepped protection of double end fed lines-need for carrier–Aided protection–Various options for a carrier–Coupling and trapping the carrier into the desired line section-Unit type carrier aided directional comparison relaying–Carrier aided distance schemes for acceleration of zone II; numerical example for a typical distance protection scheme for a transmission line.

| UNIT IV | GENERATOR PROTECTION | 9 |
|---|---|---|

Electrical circuit of the generator–Various faults and abnormal operating conditions–Stator Winding Faults–Protection against Stator(earth) faults–third harmonic voltage protection–Rotor fault–Abnormal operating conditions-Protection against Rotor faults–Potentiometer Method – injection method – Pole slipping– Loss of excitation– Protection against Mechanical faults; Numerical examples for typical generator protection schemes.

| UNIT V | NUMERICAL PROTECTION | 9 |
|---|---|---|

Introduction–Block diagram of numerical relay-Sampling theorem-Correlation with a reference wave–Least error squared (LES) technique -Digital filtering-numerical over-Current protection– Numerical transformer differential Protection-Numerical distance protection of transmission line.

| | **Total Periods** | **45** |
|---|---|---|

| **Suggestive Assessment Methods** | | |
|---|---|---|
| **Continuous Assessment Test (30 Marks)** | **Formative Assessment Test (10 Marks)** | **End Semester Exams (60 Marks)** |
| ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** | **1.ASSIGNMENT**<br>**2. ONLINE QUIZZES**<br>**3.PROBLEM-SOLVING ACTIVITIES** | ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** |

**Outcomes**

**Upon completion of the course, the students will be able to:**

**CO 1:** Learners will be able to understand the various schemes available in Transformer protection.

**CO 2:** Learners will have knowledge on Over current protection.

**CO 3:** Learners will attain knowledge about Distance and Carrier protection in transmission lines.

**CO 4:** Learners will understand the concepts of Generator protection.

**CO 5:** Learners will attain basic knowledge on substation automation.

**Reference Books**

1. Y.G.Paithankar and S.RBhide, "Fundamentals of Power System Protection", Prentice-Hall ofIndia,2003.
2. Badri Ram and D.N.Vishwakarma, "Power System Protection and Switch gear", TataMcGraw-Hill Publishing Company,2002.
3. T.S.M.Rao, "Digital Relay/Numerical relays",Tata McGrawHill,NewDelhi,1989.
4. P.Kundur, "Power System Stability and Control", McGraw-Hill,1993.

**Web Recourses**

1. https://nptel.ac.in/courses/108101039/

CO Vs PO Mapping and CO Vs PSO Mapping

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | | | | | | | | | 3 | | |
| 2 | 2 | | | | | | | | | 3 | | 3 |
| 3 | 2 | | | | | | | | | 3 | 2 | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 2 | | | | | | | | | 3 | | 3 |
| 5 | 2 | | 3 | | | | | 3 | | 3 | 2 | |

| **Course Code** | **POWER SYSTEMS STABILITY** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|
| **21PS2602** | | **3** | **0** | **0** | **3** |

**Prerequisites for the course**

- Power System
- Power System Analysis

**Objectives**

1. To understand the fundamental concepts of stability of power systems and its classification.
2. To expose the students to dynamic behaviour of the power system for small and large disturbances
3. To understand and enhance the stability of power systems
4. To understand knowledge about small-signal stability
5. To understand the various components of a power system during normal operating conditions and during disturbances

| **UNIT I** | **INTRODUCTION TO STABILITY** | **9** |
|---|---|---|

Fundamental concepts - Stability and energy of a system - Power System Stability: Definition, Causes, Nature and Effects of disturbances, Definitions, classification of stability-rotor angle and voltage stability, synchronous machine representation for stability study Modelling of electrical components - Basic assumptions made in stability studies- Modelling of Synchronous machine for stability studies (classical model) - Rotor dynamics and the swing equation.

| **UNIT II** | **SMALL-SIGNAL STABILITY** | **9** |
|---|---|---|

| | | |
|---|---|---|
| Basic concepts and definitions – State space representation, Physical Interpretation of small–signal stability, Eigen properties of the state matrix: Eigenvalues and eigenvectors, modal matrices, eigenvalue and stability, mode shape and participation factor. Small– signal stability analysis of a Single-Machine Infinite Bus (SMIB) Configuration with numerical example. | | |
| **UNIT III** | **TRANSIENT STABILITY** | **9** |
| Assumptions for transient stability, derivation of swing equation, swing equation for synchronous machine connected to infinite bus, swing equation for a two machine system, solution of swing equation by Euler and Runge Kutta method, equal area criterion, critical clearing angle, application of critical clearing angle to transient stability of synchronous machine. Methods of improving transient stability: reducing fault clearance time, automatic reclosing, single phase reclosing, electric braking, voltage regulators, fast governor action, high speed excitation system. | | |
| **UNIT IV** | **VOLTAGE STABILITY** | **9** |
| Definition and classification of voltage stability, mechanism of voltage collapse, analytical concept of voltage stability for a two bus system, expression for critical receiving end voltage and critical power angle at voltage stability limit for a two bus power system, PV and QV curves, L index for the assessment of voltage stability. | | |
| **UNIT V** | **ENHANCEMENT OF SMALL-SIGNAL STABILITY AND TRANSIENT STABILITY** | **9** |
| Power System Stabilizer –. Principle behind transient stability enhancement methods: highspeed fault clearing, regulated shunt compensation, dynamic braking, reactor switching, independent pole-operation of circuit-breakers, single-pole switching, fast- valving, high-speed excitation systems. | | |
| | **Total Periods** | **45** |
| **Suggestive Assessment Methods** | | |

| | | |
|---|---|---|
| **Continuous Assessment Test** | **Formative Assessment Test** | **End Semester Exams** |

| **(30 Marks)** | **(10 Marks)** | **(60 Marks)** |
|---|---|---|
| ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** | **1.ASSIGNMENT**<br>**2. ONLINE QUIZZES**<br>**3.PROBLEM-SOLVING ACTIVITIES** | ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** |

**Outcomes**

**Upon completion of the course, the students will be able to:**

**CO 1:** Learners will have knowledge on restructuring of power industry

**CO 2:** Learners will understand basics of congestion management

**CO 3:** Learners will attain knowledge about locational margin prices and financial transmission rights

**CO 4:** Learners will understand the significance ancillary services and pricing of transmission network

**CO 5:** Learners will have knowledge on the various power sectors in India.

**Reference Books**

**TEXT BOOK(S):**


1. Power system stability and control, P. Kundur; edited by Neal J. Balu, Mark G. Lauby, McGraw-Hill, 1994.
2. R.Ramnujam," Power System Dynamics Analysis and Simulation, PHI Learning Private Limited, New Delhi, 2009
3. T.V. Cutsem and C.Vournas, "Voltage Stability of Electric Power Systems", Kluwer publishers, 1998
4. 1. A. Chakrabarti,M.L. Soni, P. V. Gupta, U. S. Bhatnagar "A text book on Power System Engineering", Dhanpat Rai and Co.


**REFERENCE BOOK(S):**


1. Peter W., Saucer, Pai M.A., "Power System Dynamics and Stability, Pearson Education (Singapore), 9th Edition, 2007.
2. EW. Kimbark., "Power System Stability", John Wiley & Sons Limited, New Jersey, 2013.
3. SB. Crary., "Power System Stability", John Wiley & Sons Limited, New Jersey, 1955.
4. K.N. Shubhanga, "Power System Analysis" Pearson, 2017.
5. Power systems dynamics: Stability and control / K.R. Padiyar, BS Publications, 2008
6. Power system control and Stability P.M. Anderson, A.A. Foud, Iowa State University Press, 1977.


**Web Recourses**

1. https://www.cet.edu.in/noticefiles/230_power_system_stability.pdf
2. https://lecturenotes.in/subject/969/power-system-analysis-stability-psas
3. https://nptel.ac.in/courses/108/106/108106026/

CO Vs PO Mapping and CO Vs PSO Mapping

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | | | | | | | | | 3 | | |
| 2 | 2 | | | | | | | | | 3 | | 3 |
| 3 | 2 | | | | | | | | | 3 | 2 | |
| 4 | 2 | | | | | | | | | 3 | | 3 |
| 5 | 2 | | 3 | | | | | 3 | | 3 | 2 | |

| Course Code 21PS2603 | RESTRUCTURED POWER SYSTEM | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Prerequisites for the course**

- Power System
- Protection and Switchgear

**Objectives**

1. To introduce the restructuring of power industry and market models.
2. To impart knowledge on fundamental concepts of congestion management.
3. To analyze the concepts of locational marginal pricing and financial transmission rights.
4. To Illustrate about various power sectors in India.

| UNIT I | INTRODUCTION TO RESTRUCTURING OF POWER INDUSTRY | 9 |
|---|---|---|

Introduction: Deregulation of power industry, restructuring process, Issues involved in deregulation, Deregulation of various power systems – Fundamentals of Economics: Consumer behavior, Supplier behavior, Market equilibrium, Short and long run costs, Various costs of production– Market models: Market models based on Contractual arrangements, Comparison of various market models, Electricity vis–a–vis other commodities, Market architecture, Case study.

| UNIT II | TRANSMISSION CONGESTION MANAGEMENT | 9 |
|---|---|---|

Introduction: Definition of Congestion, reasons for transfer capability limitation, Importance of congestion management, features of congestion management–Classification of congestion management methods– Calculation of ATC-Non–market methods– Market methods– Nodal pricing–Inter zonal and Intra zonal congestion management–Price area congestion management– Capacity alleviation method.

| UNIT III | LOCATIONALMARGINALPRICESAND FINANCIAL TRANSMISSIONRIGHTS | 9 |
|---|---|---|

Mathematical preliminaries:- Locational marginal pricing–Lossless DCOPF model for LMP calculation–Loss compensated DCOPF model for LMP calculation–ACOPF model for LMP calculation–Financial Transmission rights – Risk hedging functionality -Simultaneous feasibility test and revenue adequacy–FTR issuance process: FTR auction, FTR allocation –Treatment of revenue shortfall–Secondary trading of FTRs–Flow gate rights–FTR and market power –FTR and merchant transmission investment.

| UNIT IV | ANCILLARYSERVICE MANAGEMENT AND | 9 |
|---|---|---|

| | | |
|---|---|---|
| | **PRICING OF TRANSMISSION NETWORK** | |
| Introduction of ancillary services– Types of Ancillary services–Classification of Ancillary services–Load generation balancing related services –Voltage control and reactive power support devices –Black start capability service-How to obtain ancillary service–Co-optimization of energy and reserve services-Transmission pricing–Principles–Classification – Rolled in transmission pricing methods – Marginal transmission pricing paradigm – Composite pricing paradigm–Merits and demerits of different paradigm. | | |
| **UNIT V** | **REFORMSININDIANPOWER SECTOR** | **9** |
| Introduction–Framework of Indian power sector–Reform initiatives –Availability based tariff – Electricity act 2003 – Open access issues–Power exchange–Reforms in the near future. | | |
| | **Total Periods** | **45** |

**Suggestive Assessment Methods**

| **Continuous Assessment Test (30 Marks)** | **Formative Assessment Test (10 Marks)** | **End Semester Exams (60 Marks)** |
|---|---|---|
| ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** | **1.ASSIGNMENT**<br>**2. ONLINE QUIZZES**<br>**3.PROBLEM-SOLVING ACTIVITIES** | ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** |

**Outcomes**

**Upon completion of the course, the students will be able to:**

**CO 1:** Learners will have knowledge on restructuring of power industry

**CO 2 :** Learners will understand basics of congestion management

**CO 3:** Learners will attain knowledge about locational margin prices and financial transmission rights

**CO 4 :** Learners will understand the significance ancillary services and pricing of transmission network

**CO 5:** Learners will have knowledge on the various power sectors in India.

**Reference Books**

1. Mohammad Sha hidehpour, Muwaffaq Alomoush, Marcel Dekker, "Restructured electrical powersystems:operation, tradingandvolatility"Pub.,2001.
2. Kankar Bhattacharya,Jaap E.Daadler,MathH.J. Boolen, "Operation of restructured power systems",Kluwer AcademicPub., 2001.
3. Paranjothi,S.R.**, "**Modern Power Systems**"**Paranjothi, S.R.**,**NewAgeInternational,2017.
4. Sally Hunt," Making competition work in electricity",JohnWilleyandSons Inc.2002.
5. Steven Stoft, "Power system economics: designing markets for electricity", John Wiley & Sons, 2002.

**Web Recourses**

- https://nptel.ac.in/courses/108101005/
- https://nptel.ac.in/content/storage2/courses/108101040/download/Lec-33.pdf

CO Vs PO Mapping and CO Vs PSO Mapping

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **3** | | | | | **2** | | | | **2** | | **3** |
| 2 | **3** | | | | | **2** | | | | **2** | **2** | |
| 3 | **3** | | **2** | | | **2** | | | | **2** | | **2** |
| 4 | **3** | | | | | **2** | | | | **2** | **3** | |
| 5 | **3** | | | | | **2** | | | | **2** | | **3** |

| **Course Code 21PS2604** | **ENERGY MANAGEMENT AND AUDITING** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|
| | | **3** | **0** | **0** | **3** |

**Prerequisites for the course**

- **Electrical Machines**
- **Power System Operation and Control**

**Objectives**

1. To study the concepts behind economic analysis and Load management.
2. To emphasize the energy management on various electrical equipments and metering.
3. To illustrate the concept of lighting systems and cogeneration.

| UNIT I | ENERGY SCENARIOS | 9 |
|---|---|---|

Energy Conservation, Energy Audit, Energy Scenarios, Energy Consumption, Energy Security, Energy Strategy, Clean Development Mechanism.Types of Energy Audits and Energy-Audit Methodology**:** Definition of Energy Audit, Place of Audit, Energy – Audit Methodology, Financial Analysis, Sensitivity Analysis, Project Financing Options, Energy Monitoring and Training.

| UNIT II | ENERGY CONSERVATION IN ELECTRIC MOTORS | 9 |
|---|---|---|

Motors efficiency – Motor selection – Factors affecting motor performance – Efficiency at low load – Rewound motors – Variable speed drives – Load reduction – High efficiency motors – Energy savings in transformers – Case studies.

| UNIT III | ENERGY AUDIT FOR BOILERS AND FURNACES | 9 |
|---|---|---|

Energy Audit of Boilers: Classification of Boilers, Parts of Boiler, Efficiency of a Boiler, Role of excess Air in Boiler Efficiency, Energy Saving Methods. Energy Audit of Furnaces: Parts of a Furnace, classification of Furnaces, Energy saving Measures in Furnaces, Furnace Efficiency.

| UNIT IV | ENERGY AUDIT FOR HVAC SYSTEMS | 9 |
|---|---|---|

Introduction to HVAC, Components of Air – Conditioning System, Types of Air – Conditioning Systems, Human Comfort Zone and Psychrometry, Vapour – Compression Refrigeration Cycle, Energy Use Indices, Impact of Refrigerants on Environment and Global Warming, Energy – Saving Measures in HVAC, Star Rating and Labelling by BEE.

| UNIT V | ENERGY CONSERVATION IN INDUSTRIAL LIGHTING | 9 |
|---|---|---|

Concept of lighting systems – Choice of lighting – Different lighting technologies – Energy saving – Control of lighting – Lighting standards and requirements – Light meter audit – Methods to reduce costs.

| | **Total Periods** | **45** |
|---|---|---|

**Suggestive Assessment Methods**

| **Continuous Assessment Test (30 Marks)** | **Formative Assessment Test (10 Marks)** | **End Semester Exams (60 Marks)** |
|---|---|---|
| ***1. DESCRIPTION QUESTIONS<br>2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** | ***1.ASSIGNMENT<br>2. ONLINE QUIZZES<br>3.PROBLEM-SOLVING ACTIVITIES*** | ***1. DESCRIPTION QUESTIONS<br>2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** |

**Outcomes**

**Upon completion of the course, the students will be able to:**

**CO 1:** Students will develop the ability to learn about the need for energy management and auditing process

**CO 2:** Learners will learn about basic concepts of economic analysis and load management.

**CO 3:** Students will understand the energy management on various electrical equipments.

**CO 4:** Students will have knowledge on the concepts of metering and factors influencing cost Function

**CO 5:** Students will be able to learn about the concept of lighting systems, light sources and various forms of cogeneration

**Reference Books**

1. Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, "Guide to Energy Management", Fifth Edition, The Fairmont Press, Inc., 2006
2. Eastop T.D & Croft D.R, "Energy Efficiency for Engineers and Technologists", Logman Scientific & Technical, 1990.
3. Reay D.A, "Industrial Energy Conservation", 1st edition, Pergamon Press, 1977.
4. "IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities", IEEE, 1996
5. Amit K. Tyagi, "Handbook on Energy Audits and Management", TERI, 2003.

**Web Recourses**

1. https://beeindia.gov.in/sites/default/files/1Ch3.pdf
2. https://www.emanz.org.nz/energy-management-audits

CO Vs PO Mapping and CO Vs PSO Mapping

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **2** | **2** | **1** | | | | | **2** | | | 3 | |
| 2 | **2** | **2** | **1** | | | | | **2** | | | | 2 |
| 3 | **2** | **2** | **1** | | | | | **2** | | | | 3 |
| 4 | **2** | **2** | **1** | | | | | **2** | | | 2 | |
| 5 | **2** | **2** | **1** | | | | | **2** | | | | 3 |

| Course Code 21PS2611 | ADVANCED POWER SYSTEM SIMULATION LABORATORY | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 4 | 2 |

**Prerequisites for the course**

- Power system Analysis
- Power System operation control
- Power Quality

**Objectives**

1. To Introduce the infinite bus system for single and classical machines.
2. To impart knowledge on starting characteristics of AC machines using hands on training.
3. To compute the two-bus system with STATCOM
4. To design the variable speed wind energy conversion system
5. To design the various active filters for improving the power quality

| S.No | List of Experiments | CO |
|---|---|---|
| 1 | Small-signal stability analysis of single machine-infinite bus system using classical machine model | 1 |
| 2 | Small-signal stability analysis of multi-machine configuration with classical machine model | 1 |
| 3 | Induction motor starting analysis. | 2 |
| 4 | Load flow analysis of two-bus system with STATCOM. | 2 |
| 5 | Transient analysis of two-bus system with STATCOM. | 3 |
| 6 | Available Transfer Capability calculation using an existing load flow program. | 3 |
| 7 | Study of variable speed wind energy conversion system- DFIG. | 4 |
| 8 | Study of variable speed wind energy conversion system- PMSG. | 4 |
| 9 | Computation of harmonic indices generated by a rectifier feeding a R-L load. | 5 |
| 10 | Design of active filter for mitigating harmonics. | 5 |

**Total Periods :30**

**Suggestive Assessment Methods**

| Lab Components Assessments (50 Marks) | End Semester Exams (50 Marks) |
|---|---|
| | |

**Outcomes**

**Upon completion of the course, the students will be able to:**

**Laboratory Requirements**

| |
|---|
| **CO 1:** Ability to analysis of single machine-infinite bus system using classical machine model<br>**CO 2:** Ability to analysis of starting of AC Machine<br>**CO 3:**Ability to analysis of two-bus system with STATCOM<br>**CO 4:** Understand the concept of variable speed wind energy conversion system<br>**CO 5:** Ability to design the active filter for filtering harmonics. |
| **Web Recourses** |
| • https://nptel.ac.in/courses/108105067/ |

| 21PS2911 | INNOVATIVE PROJECT | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 4 | 2 |

**Objectives**

1. To develop the ability to solve a specific problem right from its identification and literature review till the successful solution of the same.
2. To train the students in preparing project reports and to face reviews and viva voce examination.

**A project to be developed based on one or more of the following concepts.**

Rectifiers, DC-DC Converters, Inverters, cyclo-converters, DC drives, AC drives, Special Electrical Machines, Renewable Energy Systems, Linear and non-linear control systems, Power supply design for industrial and other applications, AC-DC power factor circuits, micro grid, smart grid and robotics.

| | |
|---|---|
| **Total Periods** | **30** |

| Course Code 21PS1701 | POWER DISTRIBUTION SYSTEM RELIABILITY | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Prerequisites for the course**

- Power System Analysis
- Power System Operation and Control

**Objectives**

1. To impart the concepts of Load forecasting.
2. To analysis the fundamentals of Generation system reliability.
3. To analysis the fundamentals of Transmission system reliability.
4. To illustrate the basic concepts of Expansion planning.
5. To study the fundamentals of Distribution system reliability analysis

| **UNIT I** | **LOAD FORECASTING** | **9** |
|---|---|---|

Objectives of forecasting - Load growth patterns and their importance in planning - Load forecasting Based on discounted multiple regression technique-Weather sensitive load forecasting-Determination of annual forecasting-Use of AI in load forecasting.

| **UNIT II** | **GENERATION SYSTEM RELIABILITY ANALYSIS** | **9** |
|---|---|---|

Probabilistic generation and load models- capacity outage table, recursive algorithm -Determination of LOLP and expected value of demand not served –Determination of reliability of ISO and interconnected generation systems.

| **UNIT III** | **TRANSMISSION SYSTEM RELIABILITY ANALYSIS** | **9** |
|---|---|---|

Deterministic contingency analysis-probabilistic load flow-Fuzzy load flow probabilistic transmission system reliability analysis-Determination of reliability indices like LOLP and expected value of demand not served.

| **UNIT IV** | **EXPANSION PLANNING** | **9** |
|---|---|---|

Basic concepts on expansion planning-procedure followed for integrate transmission system planning, current practice in India-Capacitor placer problem in transmission system and radial distributions system.

| **UNIT V** | **DISTRIBUTION SYSTEM PLANNING OVERVIEW** | **9** |
|---|---|---|

Basic technique and application to radial systems, sub transmission lines and distribution substations-Design primary and secondary systems-distribution system protection and coordination of protective devices.

| | **Total Periods** | **45** |
|---|---|---|

**Suggestive Assessment Methods**

| **Continuous Assessment Test** | **Formative Assessment Test** | **End Semester Exams** |
|---|---|---|

| (30 Marks) | (10 Marks) | (60 Marks) |
|---|---|---|
| ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** | **1.ASSIGNMENT**<br>**2. ONLINE QUIZZES**<br>**3.PROBLEM-SOLVING ACTIVITIES** | ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** |

**Outcomes**

**Upon completion of the course, the students will be able to:**

**CO 1:** Able to understand the concepts of Load forecasting.

**CO 2:** Analysis the techniques related to fundamentals of Generation system reliability.

**CO 3:** Analysis the techniques related to fundamentals of Transmission system reliability.

**CO 4:** Able to modelling of expansion planning of power system

**CO 5:** Able to understand the fundamental concepts of Distribution system reliability

**Reference Books**

1. Roy Billinton & Ronald N. Allan, "Reliability Evaluation of Power Systems" Springer Publication.
2. R.L. Sullivan, "Power System Planning", Tata McGraw Hill Publishing Company Ltd 1977.
3. X. Wang & J.R. McDonald, "Modern Power System Planning", McGraw Hill Book Company 1994.
4. T. Gonen, "Electrical Power Distribution Engineering", McGraw Hill Book Company 1986.
5. B.R. Gupta, "Generation of Electrical Energy",S.Chand Publications 1983.

**Web Recourses**

- https://link.springer.com/chapter/10.1007%2F978-1-84996-232-2_8
- https://ieeexplore.ieee.org/abstract/document/8614407

CO Vs PO Mapping and CO Vs PSO Mapping

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | | | | 3 | | | | 2 | 3 | |
| 2 | 2 | 3 | | | | 3 | | | | 2 | | 2 |
| 3 | 2 | 2 | | 2 | | | | | | | 3 | |
| 4 | 2 | 3 | | 2 | | 3 | | | | | | 2 |
| 5 | 2 | 3 | | 2 | | | | | | | 2 | |

| Course Code 21PE1601 | ANALYSIS AND DESIGN OF POWER ELECTRONIC CONVERTERS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Prerequisites for the course**

- Power Electronics
- Solid State Drives
- Power Electronics for Renewable Energy Sources.

**Objectives**

1. To determine the operation and characteristics of Power converters.
2. To introduce the design of power converter components.
3. To comprehend the concepts of resonant converters and AC-AC power converters.
4. To analyse and comprehend the various types of inverters.
5. To impart knowledge on multilevel inverters and Boost inverters.

| UNIT I | POWER CONVERTERS | 9 |
|---|---|---|

Single-phase and Three phase full converter and semi converter (RL, RLE load) - Dual converter – PWM rectifiers. Operation and analysis of Buck, Boost, Buck-Boost, Cuk & SEPIC – under continuous and discontinuous operation – Isolated converters: basic operation of Fly back, forward and Push-pull topologies.

| UNIT II | DESIGN OF POWER CONVERTER COMPONENTS | 9 |
|---|---|---|

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

| UNIT III | RESONANT DC-DC CONVERTERS& AC-AC CONVERTERS | 9 |
|---|---|---|

Resonant switch converters – operation and analysis of ZVS, ZCS converters comparison of ZCS/ZVS Introduction to ZVT/ZCT PWM converters. Single phase ac voltage controller – analysis with R & RL load – Three phase ac voltage controller – principle of operation of cycloconverters – single phase and three phase cycloconverters – Introduction to matrix converters.

| UNIT IV | VOLTAGE SOURCE AND CURRENT SOURCE INVERTERS | 9 |
|---|---|---|

Principle of operation of single phase full bridge inverters, Three phase Inverter: 180 degree and 120 degree conduction mode inverters – voltage control of inverters: Space vector modulation techniques .Operation of six-step thyristor inverter load – commutated inverters – Auto

sequential current source inverter (ASCI), PWM techniques for current source inverters.

| **UNIT V** | **MULTILEVEL INVERTERS, BOOST & RESONANT INVERTERS** | **9** |
|---|---|---|

Multilevel concept – diode clamped – flying capacitor – cascade type multilevel inverters - Comparison of multilevel inverters .Series and parallel resonant inverters - voltage control of resonant inverters – Class E resonant inverter – resonant DC - link inverters

| | |
|---|---|
| **Total Periods** | **45** |

**Suggestive Assessment Methods**

| **Continuous Assessment Test (30 Marks)** | **Formative Assessment Test (10 Marks)** | **End Semester Exams (60 Marks)** |
|---|---|---|
| ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** | **1.ASSIGNMENT**<br>**2. ONLINE QUIZZES**<br>**3.PROBLEM-SOLVING ACTIVITIES** | ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** |

**Outcomes**

**Upon completion of the course, the students will be able to:**

**CO 1:** To Understand and analyze various power converters working

**CO 2:** To Develop and design the power converter components.

**CO 3:** To understand and analyse the resonant converter and ac-ac converters.

**CO 4:** To understand and analyse the resonant converter and ac-ac converters of inverter.

**CO 5:** To understand and analyse Multilevel Inverters and boost inverters

**Text Books**

1. Ned Mohan,T.M Undeland and W.P Robbin, "Power Electronics: converters, Application and design" John Wiley and sons.Wiley India edition, 2006.
2. Rashid M.H., "Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Third Edition, New Delhi, 2004.
3. P.C. Sen, "Modern Power Electronics", Wheeler Publishing Co, First Edition, New Delhi, 1998.
4. P.S.Bimbra, "Power Electronics", Khanna Publishers, Eleventh Edition, 2003.
5. Simon Ang, Alejandro Oliva, "Power-Switching Converters, Second Edition, CRC Press, Taylor & Francis Group, 2010.

6. V.Ramanarayanan, "Course material on Switched mode power conversion", 2007.
7. Alex Van den Bossche and VencislavCekovValchev, "Inductors andTransformersforPowerElectronics", CRC Press, Taylor & Francis Group, 2005.
8. W. G. Hurley and W. H.Wolfle, "Transformers and Inductors for Power Electronics Theory, Design and Applications", 2013 John Wiley & Sons Ltd.
9. Marian.K.Kazimierczuk and DariuszCzarkowski, "Resonant Power Converters", John Wiley & Sons limited, 2011.
10. Jai P.Agrawal, "Power Electronics Systems", Pearson Education, Second Edition, 2002
11. Bimal K.Bose "Modern Power Electronics and AC Drives", Pearson Education, Second Edition, 2003.
12. Philip T. krein, "Elements of Power Electronics" Oxford University Press -1998.

**Web Recourses**

1. https://www.powerelectronics.com/technologies/dc-dc-converters/article/21861281/buckconverter-design-demystified
2. https://www.youtube.com/watch?v=LwPJi3jyfw0
3. http://dese.iisc.ac.in/design-of-power-converters/

CO Vs PO Mapping and CO Vs PSO Mapping

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3 | 3 | | | | | | | | 3 | | 3 |
| 2 | 3 | | 2 | | | | | | | 3 | 2 | |
| 3 | 3 | | 2 | | | | | | | 3 | | 3 |
| 4 | 3 | | 2 | | | | | | | 3 | 2 | |
| 5 | 3 | | 2 | | | | | | | 3 | 3 | |

| Course Code 21PS1702 | ELECTRICAL DISTRIBUTION SYSTEM | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Prerequisites for the course**

- Transmission system
- Power system Analysis
- Power system operation and control

| **Objectives** | | |
|---|---|---|
| 1. Ability to apply the concepts of planning and design of distribution system for utility systems<br>2. Ability to implement the concepts of voltage control in distribution system.<br>3. Ability to implement the concepts of voltage regulation<br>4. Ability to analyze the power flow in balanced and unbalanced system<br>5. Ability to implement the concepts of voltage feeder analysis. | | |
| **UNIT I** | **INTRODUCTION** | **9** |
| Distribution System-Distribution Feeder Electrical Characteristics-Nature of Loads**:** Individual Customer Load, Distribution Transformer Loading and Feeder Load-Approximate Method of Analysis: Voltage Drop, Line Impedance, "*K*" Factors, Uniformly Distributed Loads. | | |
| **UNIT II** | **DISTRIBUTION SYSTEM PLANNING** | **9** |
| Factors effecting planning, present techniques, planning models, future nature of distribution planning, Role of computer in Distribution planning. Load forecast, Load characteristics and Load models. | | |
| **UNIT III** | **DISTRIBUTION SYSTEM LINE MODEL** | **9** |
| Exact Line Segment Model-Modified Line Model-Approximate Line Segment Model-Modified "Ladder" Iterative Technique-General Matrices for Parallel Lines. | | |
| **UNIT IV** | **VOLTAGE REGULATION** | **9** |
| Standard Voltage Ratings-Two-Winding Transformer Theory-Two-Winding Autotransformer-Step-Voltage Regulators: Single-Phase Step-Voltage Regulators-Three-Phase Step-Voltage Regulators- Application of capacitors in Distribution system. | | |
| **UNIT V** | **DISTRIBUTION FEEDER ANALYSIS** | **9** |
| Power-Flow Analysis- Ladder Iterative Technique -Unbalanced Three-Phase DistributionFeeder-Modified Ladder Iterative Technique- Load Allocation- Short-Circuit Studies. | | |
| | **Total Periods** | **45** |
| **Suggestive Assessment Methods** | | |
| **Continuous Assessment Test (30 Marks)** | **Formative Assessment Test (10 Marks)** | **End Semester Exams (60 Marks)** |

| | | |
|---|---|---|
| ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** | **1.ASSIGNMENT**<br>**2. ONLINE QUIZZES**<br>**3.PROBLEM-SOLVING ACTIVITIES** | ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** |

**Outcomes**

**Upon completion of the course, the students will be able to:**

**CO 1:** Ability to apply the concepts of planning and design of distribution system for utility system

**CO 2:** Ability to apply the concepts of distribution system for utility system

**CO 3:** Ability to implement the concepts of voltage control in distribution system line model

**CO 4:** Ability to implement the concepts of voltage regulation in distribution system

**CO 5 :** Ability to analyze the power flow in balanced and unbalanced system

**Reference Books**

1. William H. Kersting," Distribution System Modeling and Analysis" CRC press 3rd edition,2012.
2. TuranGonen, "Electric Power Distribution System Engineering", McGraw Hill Company. 1986
3. James Northcote – Green, Robert Wilson, "Control and Automation of Electrical Power Distribution Systems", CRC Press, New York, 2007.
4. Pabla H S, "Electrical Power Distribution Systems", Tata McGraw Hill. 2004.

**Web Recourses**

- https://nptel.ac.in/courses/108107112/

CO Vs PO Mapping and CO Vs PSO Mapping

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 2 | | | | | | | | 3 | | |
| 2 | 2 | 2 | | | | | | 3 | | 3 | | |
| 3 | 2 | | | | 3 | | | 3 | | 3 | | |
| 4 | 2 | | 2 | | 3 | | | | | 3 | | |
| 5 | 2 | | 2 | | | | | | | 3 | | |

| Course Code 21PS1703 | COMPUTER AIDED POWER SYSTEM ANALYSIS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Prerequisites for the course**

Power System Analysis

**Objectives**

1. To update the knowledge in the emerging and upcoming topics in power system analysis.
2. To make the students conversant with the different software used for computer aided power system analysis i.e., the students should be able to write algorithms and implement computer programs to find out Y-bus matrix
3. To Solve power flow equations
4. To analyse Economic load dispatch problems in power flow studies
5. To implement Artificial intelligence (AI) in power system studies

| UNIT I | NETWORK FORMULATION AND GRAPH THEORY | 9 |
|---|---|---|

Introduction, Network Equations, Graph Theory, Development of Network Matrices from Graph Theoretic Approach, Augment Cut-set Incidence Matrix Cut-set and Circuit Equations, Building Algorithm for the Bus Impedance Matrix Modification of ZBUS matrix due to changes in the primitive network

| UNIT II | LOAD FLOW STUDIES | 9 |
|---|---|---|

Introduction, Different techniques such as Gauss Saidal method, Newton Raphson method, De-Coupled method, Fast Decoupled method, Modified Fast Decoupled, Concept of Optimal Power Flow, Solution of Optimal power flow by Gradient method, Solution of Optimal power flow by Newton's method Linear Programming Methods, DC load flow, Continuation Power flow.

| UNIT III | CONTINGENCY ANALYSIS | 9 |
|---|---|---|

Introduction, Factors Affecting Power System Security, Short Circuit Studies of a Large Power System Networks, Symmetrical Fault Analysis Using Bus Impedance Matrix, Algorithm for Formation of Bus Impedance Matrix, Contingency Analysis: Detection of Network Problems, Overview of security analysis, Linear Sensitivity Factors, Contingency Selection, Concentric Relaxation, Bounding

| UNIT IV | INTRODUCTION TO STATE ESTIMATION IN POWER SYSTEMS | 9 |
|---|---|---|

Introduction, Power system state estimation, Maximum Likelihood Concept , Weighted Least Squares Estimation, Introduction, Matrix Formulation, State Estimation of an AC network, Development of Method, State Estimation by Orthogonal Decomposition, An Introduction to Advanced topics in state estimation, Detection and Identification of Bad measurements, Estimation of quantities not being measured, Network Observability and Pseudo measurements, Application of Power Systems State Estimation

| **UNIT V** | **NUMERICAL INTEGRATION TECHNIQUES** | **9** |
|---|---|---|

Numerical integration techniques: One step methods, Taylor series based methods, Forward - Euler's method, Runge-Kutta methods, Trapezoidal method, backward-Euler's method, Accuracy and error analysis, Numerical stability analysis, Stiff systems, Step-size selection, Differential algebraic systems, triangular factorization, Power system applications: Transient stability analysis

| | |
|---|---|
| **Total Periods** | **45** |

**Suggestive Assessment Methods**

| **Continuous Assessment Test (30 Marks)** | **Formative Assessment Test (10 Marks)** | **End Semester Exams (60 Marks)** |
|---|---|---|
| ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** | **1.ASSIGNMENT**<br>**2. ONLINE QUIZZES**<br>**3.PROBLEM-SOLVING ACTIVITIES** | ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** |

**Outcomes**

**Upon completion of the course, the students will be able to:**

**CO 1:** Recent techniques and computer application for modeling of practical and large interconnected power system networks using programming languages.

**CO 2:** Recent methodologies for simulation and analysis of power system networks like real and reactive power flows and optimal scheduling.

**CO 3:** Effect of outage of any important component of power system on the operation and reliability of power systems.

**CO 4:** Algorithm required finding out parameters for monitoring and control of power system in real time from actual measurement data.

**CO 5:** Computer Algorithms used to solve algebro-differential pertaining to power system to assess the stability performance of power systems.

**Text Books**

1. Arthur R. Bergen, Vijay Vittal, Power Systems Analysis (English) 2nd Edition, Pearson Higher Education
2. G.L.Kusic, Computer Aided Power System Analysis, PHI, 1989
3. John J. Grainger, William D. Stevenson, Jr., Power System Analysis, Tata McGraw-Hill Series in Electrical and Computer Engineering.
4. M. A. Pai, Computer Techniques in Power Systems Analysis, Tata McGraw-Hill, Second edition 2005.


**Reference Books**


1. J.Nagrath and D.P.Kothari, "Modern Power System Analysis", Tata McGraw Hill, 1980
2. J. Arriliga and N.R. Watson, Computer modelling of Electrical power systems, 2/e, John Wiley, 2001
3. LP. Singh, “Advanced Power System Analysis and Dynamics”, 3/e, New Age Intl, 1996.
4. Stagg and El Abiad, "Computer methods in Power system Analysis", McGraw Hill,1968.


**Web Recourses**

https://www.unitech.no/power-system-

CO Vs PO Mapping and CO Vs PSO Mapping

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 2 | 2 | | | | | 2 | 2 | | |
| 2 | 2 | 3 | 2 | 2 | | | | | 2 | 2 | | |
| 3 | 1 | 1 | 2 | 2 | | | | | 2 | 2 | | |
| 4 | 2 | 1 | 2 | 2 | 3 | | | | 2 | 2 | | |
| 5 | 2 | 1 | 3 | 2 | | | | | 2 | 2 | | |

| Course Code 21PS2701 | PRINCIPLES OF SMART GRID | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Prerequisites for the course**

- Transmission & Distribution
- Power System Analysis

**Objectives**

1. To Study about Smart Grid technologies, different smart meters and advanced metering infrastructure.
2. To familiarize the power quality management issues in Smart Grid.
3. To familiarize the high performance computing for Smart Grid applications.

| UNIT I | INTRODUCTION | 9 |
|---|---|---|

| | | |
|---|---|---|
| Evolution of Electric Grid - Definitions, Architecture and Concept of Smart Grid - Need of Smart Grid - Functions of Smart Grid - Opportunities & Barriers of Smart Grid - Difference between conventional & smart grid - Difference between smart grid and Microgrid - Present development & International policies in Smart Grid - Smart grid economic and environmental benefits - Case study of Smart Grid. | | |
| **UNIT II** | **SMART GRID TECHNOLOGIES** | **9** |
| Technology Drivers, Smart energy resources, Smart substations, Substation Automation, Feeder Automation ,Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control, Distribution systems: DMS, Volt/Var control, Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV). | | |
| **UNIT III** | **SENSORS AND MEASUREMENT** | **9** |
| Sensors for Smart Grid, Monitoring and Measurement Technologies, PMU, Smart meters, Smart Appliances, Multi Agent Systems (MAS) Technology, Micro grid and Smart grid comparison, Wide Area Measurement. | | |
| **UNIT IV** | **ENERGY MANAGEMENT SYSTEM(EMS)** | **9** |
| Energy Management System (EMS) - Smart substations - Substation Automation - Feeder Automation, SCADA – Remote Terminal Unit – Intelligent Electronic Devices – Protocols, Phasor Measurement Unit – Wide area monitoring protection and control, Smart integration of energy resources – Renewable, intermittent power sources – Energy Storage. | | |
| **UNIT V** | **FACTS AND ENERGY STORAGE IN THE SMART GRID** | **9** |
| Introduction – Renewable energy generation – Fault current limiting – Shunt compensation – Series compensation – FACTS devices – HVDC-Energy storage-applications and technologies. | | |
| | **Total Periods** | **45** |

| **Suggestive Assessment Methods** | | |
|---|---|---|
| **Continuous Assessment Test (30 Marks)** | **Formative Assessment Test (10 Marks)** | **End Semester Exams (60 Marks)** |
| ***1. DESCRIPTION QUESTIONS<br>2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** | ***1.ASSIGNMENT<br>2. ONLINE QUIZZES<br>3.PROBLEM-SOLVING ACTIVITIES*** | ***1. DESCRIPTION QUESTIONS<br>2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** |
| **Outcomes** | | |
| **Upon completion of the course, the students will be able to:** | | |

**CO 1:** Learners will develop more understanding on the concepts of Smart Grid and its present developments.

**CO 2:** Learners will study about different Smart Grid technologies.

**CO 3:** Learners will acquire knowledge about different smart meters and advanced metering infrastructure.

**CO 4:** Learners will have knowledge on power quality management in Smart Grids.

**CO 5:** Learners will develop more understanding on LAN, WAN and Cloud Computing for Smart Grid applications.

**Reference Books**


1. Stuart Borlase "Smart Grid :Infrastructure, Technology and Solutions", CRC Press 2012.
2. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", Wiley 2012.
3. Vehbi C. Güngör, DilanSahin, TaskinKocak, Salih Ergüt, ConcettinaBuccella, Carlo Cecati, and Gerhard P. Hancke, "Smart Grid Technologies: Communication Technologies and Standards" IEEE Transactions On Industrial Informatics, Vol. 7, No. 4, November 2011.
4. Xi Fang, SatyajayantMisra, Guoliang Xue, and Dejun Yang "Smart Grid – The NewandImproved Power Grid: A Survey" , IEEE Transaction on Smart Grids, vol. 14, 2012.
5. SawanSen ,SamarjitSengupta, AbhijitChakrabarti , "Electricity pricing- regulated, deregulated and smart grid systems", CRC press, 2015.
6. Mini S. Thomas and John Douglas McDonald, "Power system SCADA and smart grids", CRC press, 2015.


**Web Recourses**

1. https://nptel.ac.in/courses/108/107/108107113/
2. http://www.digimat.in/nptel/courses/video/108107113/108107113.html
3. http://www.digimat.in/nptel/courses/video/108107113/108107113.html

CO Vs PO Mapping and CO Vs PSO Mapping

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3 | | 3 | | | 2 | | | 2 | 2 | | |
| 2 | 3 | | 3 | | | 2 | | | 2 | 2 | | |
| 3 | 3 | | 3 | | | 2 | | | 2 | 2 | | |
| 4 | 3 | | 3 | | | 2 | | | 2 | 2 | | |
| 5 | 3 | | 3 | | | 2 | | | 2 | 2 | | |

| Course Code 21PE2601 | GENERALIZED MACHINE THEORY | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 1 | 0 | 4 |

**Prerequisites for the course**

- Electrical Machines
- Electrical Machines Design

**Objectives**

1. To impart knowledge on the following topics.
2. To develop the basic elements of generalized theory
3. To derive the general equations for voltages and torque of all type of rotating machines
4. To develop the simulation model of three-phase AC machines
5. To deal with the steady state and transient analysis of rotating machines.

| UNIT I | INTRODUCTION | 12 |
|---|---|---|

Reference frame theory, 3-Φ→2-Φ transformation, Physical concept of park's transformation, Volt-ampere and torque equations, Space vector concept.

| UNIT II | THREE PHASE INDUCTION MACHINE | 12 |
|---|---|---|

Performance equations in different rotating frames, Equivalent circuit, Different inductance, Effect of voltage and frequency on the performance, Braking, Unbalance operations.

| UNIT III | SYNCHRONOUS MACHINE | 12 |
|---|---|---|

General machine equation in different frame, Dynamic analysis, Transient Power angle characteristics, Phases diagram for cylindrical rotor and salient pole machine, Electromagnetic and reluctance torque, Electric braking of synchronous machine.

| UNIT IV | DC MACHINE | 12 |
|---|---|---|

Transfer function for DC machine, (Shunt, Series and compound), Linearization technique, Analysis under motoring and generating mode, Dynamic analysis.

| UNIT V | APPLICATION | 12 |
|---|---|---|

Application of generalized theory to separately excited, shunt, series and compound machines, Steady state and transient analysis, 2-Φ servomotor, AC tachometers,Switched

| | |
|---|---|
| reluctance motor. | |
| **Total Periods** | **45** |

**Suggestive Assessment Methods**

| **Continuous Assessment Test (30 Marks)** | **Formative Assessment Test (10 Marks)** | **End Semester Exams (60 Marks)** |
|---|---|---|
| ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** | **1.ASSIGNMENT**<br>**2. ONLINE QUIZZES**<br>**3.PROBLEM-SOLVING ACTIVITIES** | ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** |

**Outcomes**

**Upon completion of the course, the students will be able to:**

**CO 1:** Ability to understand the various electrical parameters in mathematical form

**CO 2:** Ability to understand the different types of reference frame theories and transformation relationships.

**CO 3:** Ability to find the electrical machine equivalent circuit parameters and modeling of electrical machines.

**CO 4:** Ability to know about the equivalent circuit parameters and modeling of Induction machines

**CO 5:** Ability to know about the equivalent circuit parameters and modeling of Synchronous machines

**Reference Books**

1. Paul C.Krause, Oleg Wasyzczuk, Scott S, Sudhoff, "Analysis of Electric Machinery and Drive Systems", John Wiley, Second Edition, 2010.
2. P S Bimbhra, "Generalized Theory of Electrical Machines", Khanna Publishers, 2008.
3. A.E, Fitzgerald, Charles Kingsley, Jr, and Stephan D, Umanx, "Electric Machinery", Tata McGraw Hill, 5th Edition, 1992.
4. R. Krishnan, Electric Motor & Drives: Modeling, Analysis and Control, New Delhi, Prentice Hall of India, 2001.

**Web Recourses**

1. https://nptel.ac.in/content/syllabus_pdf/108106023.pdf
2. https://nptel.ac.in/courses/108106023/

CO Vs PO Mapping and CO Vs PSO Mapping

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **2** | **1** | **2** | | | | | **2** | | | 3 | 2 |
| 2 | **2** | **1** | **2** | | | | | **2** | | | 2 | |
| 3 | **2** | **1** | **2** | | | | | **2** | | | | 3 |
| 4 | **2** | **1** | **2** | | | | | **2** | | | 2 | |
| 5 | **2** | **1** | **2** | | | | | **2** | | | | 2 |

| **Course Code 21PE2603** | **MODERN CONTROL THEORY** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|
| | | **3** | **0** | **0** | **3** |

**Prerequisites for the course**

UG level Control system

**Objectives**

1. To understand the fundamentals of physical systems in terms of its linear and nonlinear models.
2. To educate on representing systems in state variable form.
3. To educate on solving linear and non-linear state equations.
4. To exploit the properties of linear systems such as controllability and observability.
5. To educate on stability analysis of systems using Lyapunov's theory.
6. To educate on modal concepts and design of state and output feedback controllers and estimators.

| **UNIT I** | **NONLINEAR CONTROL SYSTEM** | **12** |
|---|---|---|

Introduction to Nonlinear systems and their properties, Common Non-linearities, Describing functions, Phase plane method, Lyapounov's method for stability study, concept of Limit Cycle.

| **UNIT II** | **OPTIMAL CONTROL THEORY** | **12** |
|---|---|---|

Introduction, Optimal control problems, Mathematical procedures for optimal control design: Calculus of variations, Pontryagin's optimum policy, Bang-Bang Control, Hamilton-Jacobi Principle.

| **UNIT III** | **Z-PLANE ANALYSIS OF DISCRETE-TIME CONTROL SYSTEMS** | **12** |
|---|---|---|

Introduction, Impulse sampling and data hold, Reconstructing original signal from sampled signals, concept of pulse transfer function, Realization of digital controllers.

| **UNIT IV** | **DESIGN OF DISCRETE-TIME CONTROL SYSTEMS** | **12** |
|---|---|---|

| | | |
|---|---|---|
| Introduction, Stability analysis of closed-loop systems in the z-plane, Transient and steady state response analysis, Design based on the rootlocus method, Design based on the frequency-response method. | | |
| **UNIT V** | **STATE-SPACE ANALYSIS** | **12** |
| Introduction, State-space representations of discrete-time systems, Solving discrete-time state-space equations, Pulse transfer function matrix, Discretization of continuous time state space equations, Lyapunov stability analysis, Controllability and Observability, Design via pole placement, State observer design. | | |
| | **Total Periods** | **45** |

**Suggestive Assessment Methods**

| **Continuous Assessment Test (30 Marks)** | **Formative Assessment Test (10 Marks)** | **End Semester Exams (60 Marks)** |
|---|---|---|
| ***1. DESCRIPTION QUESTIONS 2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** | ***1.ASSIGNMENT 2. ONLINE QUIZZES 3.PROBLEM-SOLVING ACTIVITIES*** | ***1. DESCRIPTION QUESTIONS 2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** |

**Outcomes**

**Upon completion of the course, the students will be able to:**

**CO 1:** Demonstrate non-linear system behavior by phase plane and describing function methods.

**CO 2:** Perform the stability analysis nonlinear systems by lyapunov method develop design skills in optimal control problems.

**CO 3:** Derive discrete-time mathematical models in both time domain (difference equations, state equations) and z-domain (transfer function using z-transform).

**CO 4:** Predict and analyze transient and steady-state responses and stability and sensitivity of both open-loop and closed-loop linear, time-invariant, discrete-time control systems.

**CO 5:** Use the techniques such as describing function, Lyapunov Stability, Popov's Stability Criterion and Circle Criterion to assess the stability of certain class of non-linear system.

**Reference Books**

1. M. Gopal, "Modern Control System Theory", New Age International, 2005.
2. K. Ogatta, "Modern Control Engineering", PHI, 2002.
3. John S. Bay, "Fundamentals of Linear State Space Systems", McGraw-Hill, 1999.
4. D. Roy Choudhury, "Modern Control Systems", New Age International, 2005.
5. John J. D'Azzo, C. H. Houpis and S. N. Sheldon, "Linear Control System Analysis and Design with MATLAB", Taylor Francis, 2003.
6. Z. Bubnicki, "Modern Control Theory", Springer, 2005.

7. C.T. Chen, "Linear Systems Theory and Design'' Oxford University Press, 3rd Edition,1999.
8. Bandyopadhyay, M.N., Control Engineering: Theory and Practice, Prentice-Hall of India Private Limited (2003).
9. Ogata, K., Discrete-time Control Systems, Pearson Education (2005).

**Web Recourses**

1. https://nptel.ac.in/courses/108106150/

CO Vs PO Mapping and CO Vs PSO Mapping

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3 | 3 | 3 | 2 | | | | | 1 | | 3 | |
| 2 | 3 | 3 | 3 | 2 | | | | | 1 | | | 2 |
| 3 | 3 | 3 | 3 | 2 | | | | | 1 | | 3 | |
| 4 | 3 | 3 | 3 | 2 | | | | | 1 | | | 2 |
| 5 | 3 | 3 | 3 | 2 | | | | | 1 | | 3 | |

| Course Code 21PS2702 | FLEXIBLE AC TRANSMISSION SYSTEMS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Prerequisites for the course**

- High Voltage Direct Current Engineering
- High Voltage Engineering.

**Objectives**

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

| UNIT I | INTRODUCTION | 9 |
|---|---|---|

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

| | | |
|---|---|---|
| **UNIT II** | **STATIC VAR COMPENSATOR (SVC)** | **9** |
| Configuration of SVC- voltage regulation by SVC- Modelling of SVC for load flow analysis Modelling of SVC for stability studies-Design of SVC to regulate the mid-point voltage ofa SMIB system- Applications: transient stability enhancement and power oscillation damping of SMIB system with SVC connected at the mid-point of the line. | | |
| **UNIT III** | **THYRISTOR AND GTO THYRISTOR CONTROLLED SERIES CAPACITORS (TCSC and GCSC)** | **9** |
| Concepts of Controlled Series Compensation – Operation of TCSC and GCSC- Analysis of TCSC-GCSC – Modelling of TCSC and GCSC for load flow studies- modelling TCSC and GCSC for stability studied- Applications of TCSC and GCSC. | | |
| **UNIT IV** | **VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS** | **9** |
| Static synchronous compensator(STATCOM)- Static synchronous series compensator(SSSC)- Operation of STATCOM and SSSC-Power flow control with STATCOM and SSSC- Modelling of STATCOM and SSSC for power flow and transient stability studies –operation of Unified and Interline power flow controllers(UPFC and IPFC)- Modelling of UPFC and IPFC for load flow and transient stability studies- Applications. | | |
| **UNIT V** | **CONTROLLERS AND THEIR COORDINATION** | **9** |
| FACTS Controller interactions – SVC–SVC interaction - co-ordination of multiple controllers using linear control techniques – Quantitative treatment of control coordination. | | |
| | **Total Periods** | **45** |

**Suggestive Assessment Methods**

| **Continuous Assessment Test (30 Marks)** | **Formative Assessment Test (10 Marks)** | **End Semester Exams (60 Marks)** |
|---|---|---|
| ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** | **1.ASSIGNMENT**<br>**2. ONLINE QUIZZES**<br>**3.PROBLEM-SOLVING ACTIVITIES** | ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** |

**Outcomes**

**Upon completion of the course, the students will be able to:**

**CO 1:** Ability to understand the operation of the ac transmission lines and various types of FACTS.

**CO 2:** Ability to understand the basic concepts of VAR compensators.

**CO 3:** Ability to know about the modeling and applications of thyistors and GTO.

**CO 4:** Ability to understand the basic concepts voltage source convertor based FACTS.

**CO 5:** Ability to analysis the various Controllers and their Coordination.

**Reference Books**


1. A.T.John, "Flexible AC Transmission System", Institution of Electrical and Electronic Engineers (IEEE), 1999.
2. NarainG.Hingorani, Laszio. Gyugyl, "Understanding FACTS Concepts and Technology of Flexible AC Transmission System", Standard Publishers, Delhi 2001.
3. V. K.Sood, "HVDC and FACTS controllers- Applications of Static Converters in Power System", 2004, Kluwer Academic Publishers.
4. Mohan Mathur, R., Rajiv. K. Varma, "Thyristor – Based Facts Controllers for Electrical Transmission Systems", IEEE press and John Wiley & Sons, Inc.
5. K.R.Padiyar," FACTS Controllers in Power Transmission and Distribution", New Age International(P) Ltd., Publishers New Delhi, Reprint 2008.


**Web Recourses**

1. https://www.electrical4u.com/facts-on-facts-theory-and-applications/
2. https://www.gegridsolutions.com/facts.htm

CO Vs PO Mapping and CO Vs PSO Mapping

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 2 | 1 | 2 | | | | 2 | | | | 3 |
| 2 | 2 | 2 | 1 | 2 | | | | 2 | | | 2 | |
| 3 | 2 | 2 | 1 | 2 | | | | 2 | | | 3 | |
| 4 | 2 | 2 | 1 | 2 | | | | 2 | | | | 2 |
| 5 | 2 | 2 | 1 | 2 | | | | 2 | | | | 3 |

| Course Code | DISTRIBUTED GENERATION AND MICROGRID | L | T | P | C |
|---|---|---|---|---|---|
| 21PS2703 | | 3 | 0 | 0 | 3 |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |

**Prerequisites for the course**

- Power Electronics
- Power Generation Systems
- Solid state drives
- Power system operation and control

**Objectives**

1. To illustrate the concept of distributed generation
2. To impart knowledge on Distributed Generation
3. To analyse the impact of grid integration.
4. To study concept of Micro grid and its configuration
5. To impart knowledge on Microgrid

| UNIT I | INTRODUCTION | 9 |
|---|---|---|

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

| UNIT II | DISTRIBUTED GENERATIONS (DG) | 9 |
|---|---|---|

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

| UNIT III | IMPACT OF GRID INTEGRATION | 9 |
|---|---|---|

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

| UNIT IV | BASICS OF A MICROGRID | 9 |
|---|---|---|

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

| UNIT V | CONTROL AND OPERATION OF MICROGRID | 9 |
|---|---|---|

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

| | |
|---|---|
| **Total Periods** | **45** |

**Suggestive Assessment Methods**

| **Continuous Assessment Test (30 Marks)** | **Formative Assessment Test (10 Marks)** | **End Semester Exams (60 Marks)** |
|---|---|---|
| ***1. DESCRIPTION QUESTIONS<br>2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** | ***1.ASSIGNMENT<br>2. ONLINE QUIZZES<br>3.PROBLEM-SOLVING ACTIVITIES*** | ***1. DESCRIPTION QUESTIONS<br>2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** |

**Outcomes**

**Upon completion of the course, the students will be able to:**

**CO 1:** Learners will attain knowledge on the various schemes of conventional and nonconventional power generation.

**CO 2 :** Learners will have knowledge on the topologies and energy sources of distributed generation.

**CO 3:** Learners will learn about the requirements for grid interconnection and its impact with NCE sources.

**CO 4:** Learners will understand the fundamental concept of Microgrid.

**CO 5:** Learners will understand the control and operation of Microgrid.

**Reference Books**

1. AmirnaserYezdani, and Reza Iravani, "Voltage Source Converters in Power Systems: Modeling, Control and Applications", IEEE John Wiley Publications, 2010.
2. DorinNeacsu, "Power Switching Converters: Medium and High Power", CRC Press,Taylor& Francis, 2006.
3. Chetan Singh Solanki, "Solar Photo Voltaics", PHI learning Pvt. Ltd., New Delhi,2009.
4. J.F. Manwell, J.G. McGowan "Wind Energy Explained, theory design and applications", Wiley publication 2010.
5. D. D. Hall and R. P. Grover, "Biomass Regenerable Energy", John Wiley, New York, 1987.
6. John Twidell and Tony Weir, "Renewable Energy Resources" Tyalor and Francis Publications,

Second edition 2006.

**Web Recourses**

- https://nptel.ac.in/courses/108107143/
- https://nptel.ac.in/courses/108/108/108108034/

CO Vs PO Mapping and CO Vs PSO Mapping

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | | 2 | | | | | | | 3 | | 3 |
| 2 | 2 | | 2 | | | | | | | 3 | 2 | |
| 3 | 2 | | 2 | | 2 | | | | | 3 | 3 | |
| 4 | 2 | | 2 | | | | | | | 3 | | 2 |
| 5 | 2 | | 2 | | | | | | | 3 | | 2 |

| Course Code 21PE2706 | ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Prerequisites for the course**

- Electromagnetic Theory
- Transmission and Distribution
- FACTS
- Power System Analysis

**Objectives**

1. To provide fundamental knowledge on electromagnetic interference and electromagnetic compatibility.
2. To study the important techniques to control EMI and EMC.
3. To expose the knowledge on testing techniques as per Indian and international standards in EMI measurement.
4. To Study the basics of grounding and cables used in power system.
5. To understand the concepts of electrostatic discharge, standards and testing techniques.

| UNIT I | INTRODUCTION | 9 |
|---|---|---|

| | | |
|---|---|---|
| Definitions of EMI/EMC -Sources of EMI- Inter systems and Intra system- Conducted and radiated interference- Characteristics - Designing for electromagnetic compatibility (EMC)- EMC regulation typical noise path- EMI predictions and modelling, Cross talk - Methods of eliminating interferences. | | |
| **UNIT II** | **GROUNDING AND CABLING** | **9** |
| Cabling- types of cables, mechanism of EMI emission / coupling in cables –capacitive coupling inductive coupling- shielding to prevent magnetic radiation- shield transfer impedance, Grounding – safety grounds – signal grounds- single point and multipoint ground systems hybrid grounds- functional ground layout –grounding of cable shields- -guard shields- isolation, neutralizing transformers, shield grounding at high frequencies, digital grounding- Earth measurement Methods. | | |
| **UNIT III** | **BALANCING, FILTERING AND SHIELDING** | **9** |
| Power supply decoupling- decoupling filters-amplifier filtering –high frequency filtering- EMI filters characteristics of LPF, HPF, BPF, BEF and power line filter design -Choice of capacitors, inductors, transformers and resistors, EMC design components -shielding – near and far fields shielding effectiveness- absorption and reflection loss- magnetic materials as a shield, shield discontinuities, slots and holes, seams and joints, conductive gaskets-windows and coatings - grounding of shields. | | |
| **UNIT IV** | **EMI IN ELEMENTS AND CIRCUITS** | **9** |
| Electromagnetic emissions, noise from relays and switches, non-linearities in circuits, passive inter modulation, transients in power supply lines, EMI from power electronic equipment, EMI as combination of radiation and conduction. | | |
| **UNIT V** | **ELECTROSTATIC DISCHARGE, STANDARDS AND TESTING TECHNIQUES** | **9** |
| Static Generation- human body model- static discharges- ESD versus EMC, ESD protection in equipments- standards – FCC requirements – EMI measurements – Open area test site measurements and precautions- Radiated and conducted interference measurements, Control requirements and testing methods. | | |
| | **Total Periods** | **45** |

**Suggestive Assessment Methods**

| **Continuous Assessment Test (30 Marks)** | **Formative Assessment Test (10 Marks)** | **End Semester Exams (60 Marks)** |
|---|---|---|
| ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** | ***1.ASSIGNMENT***<br>***2. ONLINE QUIZZES***<br>***3.PROBLEM-SOLVING ACTIVITIES*** | ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** |

**Outcomes**

**Upon completion of the course, the students will be able to:**

**CO 1:** Recognize the sources of Conducted and radiated EMI in Power Electronic Converters and consumer appliances and suggest remedial measures to mitigate the problems.

**CO 2:** Assess the insertion loss and design EMI filters to reduce the loss.

**CO 3:** Design EMI filters, common-mode chokes and RC-snubber circuits measures to keep the interference within tolerable limits.

**CO 4:** Ability to understand the parameters of grounding and cables.

**CO 5:** Ability to use different standards and testing techniques in electrostatic discharge.

**Reference Books**

1. V.P. Kodali, "Engineering Electromagnetic Compatibility", S. Chand, 1996.
2. Henry W.Ott, " Noise reduction techniques in electronic systems", John Wiley & Sons, 1989.
3. Bernhard Keiser, "Principles of Electro-magnetic Compatibility", Artech House, Inc. (685 canton street, Norwood, MA 020062 USA) 1987.
4. Bridges, J.E Milleta J. and Ricketts.L.W., "EMP Radiation and Protective techniques", John Wiley and sons, USA 1976.
5. William Duff G., & Donald White R. J, "Series on Electromagnetic Interference and Compatibility", Vol. Weston David A., "Electromagnetic Compatibility, Principles and Applications", 1991.

**Web Recourses**

- https://www.sebokwiki.org/wiki/Electromagnetic_Interference/Electromagnetic
- https://epd.wisc.edu/courses/introduction-to-electromagnetic-interference

CO Vs PO Mapping and CO Vs PSO Mapping

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | | | | | | | | | | 3 | |
| 2 | 2 | | | | 1 | | | | | | 2 | |
| 3 | 3 | | | | 2 | | 2 | | | | | 3 |
| 4 | 3 | 2 | 2 | 3 | | | 2 | | | | | 2 |
| 5 | 2 | | 3 | | 3 | | | | | | 3 | |

| Course Code | EMBEDDED SYSTEM DESIGN | L | T | P | C |
|---|---|---|---|---|---|
| 21PE2709 | | 3 | 0 | 0 | 3 |

**Prerequisites for the course**

- Microprocessor & Microcontroller concepts and applications
- Assembly language concepts
- Operating system concepts
- Computer organization and architecture concepts
- Design analysis of different day to day equipments
- Basics of all electronics components

**Objectives**

To impart knowledge on

1. Students have knowledge about the basic functions, structure, concepts and applications of embedded systems.
2. Develop familiarity with 8051 Microcontrollers and their applications in an embedded environment.
3. To learn the method of designing and program an Embedded Systems for real time applications.
4. To understand operating system concepts, types and choosing RTOS.
5. Students have knowledge about the development of embedded software using RTOS and implement small programs to solve well-defined problems on an embedded platform.
6. Develop familiarity with tools used to develop in an embedded environment.

| UNIT I | INTRODUCTION TO EMBEDDED SYSTEMS | 9 |
|---|---|---|

Definition of Embedded System, Embedded Systems Vs General Computing Systems, History of Embedded Systems, Classification, Major Application Areas, Purpose of Embedded Systems, Characteristics and Quality Attributes of Embedded Systems.

| UNIT II | TYPICAL EMBEDDED SYSTEM | 9 |
|---|---|---|

Core of the Embedded System: General Purpose and Domain Specific Processors, ASICs, PLDs, Commercial Off-The-Shelf Components (COTS), Memory: ROM, RAM, Memory according to the type of Interface, Memory Shadowing, Memory selection for Embedded Systems, Sensors and Actuators, Communication Interface: Onboard and External Communication Interfaces.

| UNIT III | EMBEDDED FIRMWARE | 9 |
|---|---|---|

Reset Circuit, Brown-out Protection Circuit, Oscillator Unit, Real Time Clock, Watchdog Timer, Embedded Firmware Design Approaches and Development Languages.

| UNIT IV | RTOS BASED EMBEDDED SYSTEM DESIGN | 9 |
|---|---|---|

Operating System Basics, Types of Operating Systems, Tasks, Process and Threads, Multi processing and Multi-tasking, Task Scheduling.

| UNIT V | TASK COMMUNICATION | 9 |
|---|---|---|
| Shared Memory, Message Passing, Remote Procedure Call and Sockets, Task Synchronization: Task Communication/Synchronization Issues, Task Synchronization Techniques, Device Drivers, How to Choose an RTOS. | | |
| | **Total Periods** | **45** |

**Suggestive Assessment Methods**

| Continuous Assessment Test (30 Marks) | Formative Assessment Test (10 Marks) | End Semester Exams (60 Marks) |
|---|---|---|
| ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** | **1.ASSIGNMENT**<br>**2. ONLINE QUIZZES**<br>**3.PROBLEM-SOLVING ACTIVITIES** | ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** |

**Outcomes**

**Upon completion of the course, the students will be able to:**

**CO 1: Understand** basic concept of embedded systems.

**CO 2:** Apply and analyze the applications in various processors and domains of embedded system.

**CO 3:** Analyze and develop embedded hardware and software development cycles and tools.

**CO 4:** Analyze to understand what a microcomputer, core of the embedded system.

**CO 5:** Remember the definitions of ASICs, PLDs, memory, memory interface.

**Text Books**

1. Introduction to Embedded Systems - Shibu K.V, Mc Graw Hill.
2. Embedded Systems - Raj Kamal, TMH.

**Reference Books**

1. Embedded System Design - Frank Vahid, Tony Givargis, John Wiley.
2. Embedded Systems – Lyla, Pearson, 2013.
3. An Embedded Software Primer - David E. Simon, Pearson Education.

**Web Recourses**

- **http://nptel.ac.in/courses/10810205/**

CO Vs PO Mapping and CO Vs PSO Mapping

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | - | 2 | 2 | 2 | |
| 2 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | - | 2 | 2 | 2 | |
| 3 | 2 | 2 | 3 | 2 | 2 | 3 | 3 | - | 3 | 3 | | 3 |
| 4 | 2 | 2 | 2 | 3 | 3 | 3 | 2 | - | 2 | 2 | 2 | |
| 5 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | - | 2 | 2 | | 3 |

| Course Code | MODERN RECTIFIERS AND RESONANT CONVERTERS | L | T | P | C |
|---|---|---|---|---|---|
| 21PE2705 | | 3 | 0 | 0 | 3 |

**Prerequisites for the course**

- Electromagnetic filed
- Power Converters
- Power System Analysis

**Objectives**

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

| UNIT I | POWER SYSTEM HARMONICS & LINE COMMUTATED RECTIFIERS | 9 |
|---|---|---|

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

| UNIT II | PULSE WIDTH MODULATED RECTIFIERS | 9 |
|---|---|---|

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

| **UNIT III** | **RESONANT CONVERTERS** | **9** |
|---|---|---|
| Soft Switching - classification of resonant converters - Quasi resonant converters- basics ofZVS and ZCS- half wave and full wave operation (qualitative treatment) - multi resonant converters - operation and analysis of ZVS and ZCS multi resonant converter - zero voltage transition PWM converters -zero current transition PWM converters. | | |
| **UNIT IV** | **DYNAMIC ANALYSIS OF SWITCHING CONVERTERS** | **9** |
| Review of linear system analysis-State Space Averaging-Basic State Space Average Model State Space Averaged model for an ideal Buck Converter, ideal Boost Converter, ideal Buck Boost Converter and an ideal Cuk Converter. Pulse Width modulation - Voltage Mode PWM Scheme - Current Mode PWM Scheme - design of PI controller. | | |
| **UNIT V** | **SOURCE CURRENT SHAPING OF RECTIFIERS** | **9** |
| Need for current shaping - power factor - functions of current shaper - input current shaping methods - passive shaping methods -input inductor filter - resonant input filter - active methods - boost rectifier employing peak current control - average current control - Hysteresis control- Nonlinear carrier control. | | |
| | **Total Periods** | **45** |

**Suggestive Assessment Methods**

| **Continuous Assessment Test (30 Marks)** | **Formative Assessment Test (10 Marks)** | **End Semester Exams (60 Marks)** |
|---|---|---|
| ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** | ***1.ASSIGNMENT***<br>***2. ONLINE QUIZZES***<br>***3.PROBLEM-SOLVING ACTIVITIES*** | ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** |

**Outcomes**

**Upon completion of the course, the students will be able to:**

**CO 1:**Ability to analysis of various types of rectifiers.

**CO 2 :** Simulate and design the operation of various PWM converters and its applications.

**CO 3:** Identify the importance resonant converter and its importance.

**CO 4:** Design the various DC-DC converter techniques.

**CO 5:** Select small-signal modeling of a DC-DC Converter.

**Text Books**


1. Robert W. Erickson and Dragon Maksimovic, "Fundamentals of Power Electronics", Second Edition, Springer science and Business media, 2001.
2. William Shepherd and Li zhang, "Power Converters Circuits", MarceldEkkerin,C, 2005.
3. Simon Ang and Alejandro Oliva, "Power Switching Converters", Taylor & Francis Group, 2010.
4. Andrzej M. Trzynadlowski, " Introduction To Modern Power Electronics", John Wiley &Sons, 2016.
5. Marian.K.Kazimierczuk and DariuszCzarkowski, "Resonant Power Converters", John Wiley & Sons limited, 2011.
6. Keng C .Wu, "Switch Mode Power Converters – Design and Analysis" Elseveir academic press, 2006.
7. Abraham I.Pressman, Keith Billings and Taylor Morey, " Switching Power Supply Design" McGraw-Hill ,2009.
8. V.Ramanarayanan, "Course Material on Switched Mode Power Conversion" IISC, Banglore, 2007.
9. Christophe P. Basso, Switch-Mode Power Supplies, McGraw-Hill ,2014.


**Web Recourses**

https://www.scribd.com/document/372768631/PX5004-MR-RC

CO Vs PO Mapping and CO Vs PSO Mapping

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | - | 2 | 2 | 2 | |
| 2 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | - | 2 | 2 | 2 | |
| 3 | 2 | 2 | 3 | 2 | 2 | 3 | 3 | - | 3 | 3 | | 3 |
| 4 | 2 | 2 | 2 | 3 | 3 | 3 | 2 | - | 2 | 2 | 2 | |
| 5 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | - | 2 | 2 | | 3 |

| Course Code | INTEGRATED CIRCUITS FOR POWER CONVERSION | L | T | P | C |
|---|---|---|---|---|---|
| 21PE3706 | | 3 | 0 | 0 | 3 |

**Prerequisites for the course**

- **Power Converters**
- **Integrated Circuits**

**Objectives**

1. To develop the Type of Regulator in a Multi-Chip System
2. To learn the different Frequency Compensation Techniques
3. To understand the Load Regulation and Output Impedance in regulator
4. To deal with the basic Concept of a Switching Regulator.
5. To analyse the concept of Pulse Frequency Modulation

| **UNIT I** | **INTRODUCTION** | **9** |
|---|---|---|

Discrete vs. Integrated PMIC; DC-DC Converters, Types of DC-DC Converters, Linear versus Switching Regulator, Choosing between Linear and Switching Regulators, Choosing the Type of Regulator in a Multi-Chip System; Performance Parameters - Efficiency, Accuracy, Line and Load Regulation, Line and Load Transient, PSRR; Remote versus Local Feedback, Point-of-Load Regulator, Kelvin Sensing, Droop Compensation; Current Regulators and their Applications; Bandgap Voltage Reference - Designing a Bandgap Reference using PTAT and CTAT Voltage References, Brokaw Bandgap Circuit.

| **UNIT II** | **LINEAR REGULATOR** | **9** |
|---|---|---|

Introduction to Linear Regulator, Applications of Linear Regulator; Review of Feedback Systems and Bode Plots, Loop Gain AC Analysis, Stability Criterion and Phase Margin, Review of First-Order and Second-Order Systems, Relationship between Damping Factor and Phase Margin; Parasitic Capacitances in a MOS transistor, Finding the Poles of the Error Amplifier; Stabilising a Linear Regulator - Frequency Compensation Techniques, Dominant Pole Compensation.

| **UNIT III** | **MILLER COMPENSATION** | **9** |
|---|---|---|

Miller Compensation, R.H.P. zero due to Miller Compensation, Intuitive Methods of Determining Poles and Zeros after Miller Compensation, Pole Splitting due to Miller Compensation, Reducing the Effect of R.H.P. zero; LDO with NMOS Pass Element; Load Regulation and Output Impedance of LDO; Line Regulation and PSRR of LDO; Sources of Error in a Regulator.

| **UNIT IV** | **SWITCHING REGULATOR CONCEPT** | **9** |
|---|---|---|

Static Offset Correction, Dynamic Offset Cancellation;Digital LDO, Avoidance of Limit-Cycle Oscillations in a Digital LDO, Hybrid LDO; Short-Circuit Protection and Foldback Current Limit in an LDO; Basic Concept of a Switching Regulator, Inductor volt-second Balance, Power Stage of a Buck Converter and Calculation of Duty Cycle; Transformer Model of a Buck Converter, Resistive Losses, Efficiency of a Switching Regulator, Efficiency considering only Conduction Losses; Synchronous and Non-Synchronous Switching Converters; PWM Control Techniques Losses in Switching DC-DC Converter- Conduction Loss, Gate-Driver Switching Loss, Segmented Power FET.

| **UNIT V** | **PULSE FREQUENCY MODULATION CONCEPT** | **9** |
|---|---|---|
| Hard Switching Loss, Magnetic Loss, Relative Significance of Losses as a Function of the Load Current; Inductor Current Ripple and Output Voltage Ripple in a DC-DC Converter, Ripple Voltage versus Duty Cycle, Ripple Voltage versus Input Supply Voltage; Choosing the Inductor and Capacitor of a Buck Converter; Continuous and Discontinuous Conduction Modes - Boundary Condition, Voltage Conversion Ratio in DCM; Concept of Pulse Frequency Modulation (PFM); Classification of Pulse Width Modulators -- Trailing, Leading and Dual-Edge PW Modulators; Control Techniques for DC-DC Converters; Voltage Mode Control, Small-Signal Modeling of a DC-DC Converter, Loop Gain and Stability Analysis using Continuous-Time Model. | | |
| | **Total Periods** | **45** |

**Suggestive Assessment Methods**

| **Continuous Assessment Test (30 Marks)** | **Formative Assessment Test (10 Marks)** | **End Semester Exams (60 Marks)** |
|---|---|---|
| ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** | **1.ASSIGNMENT**<br>**2. ONLINE QUIZZES**<br>**3.PROBLEM-SOLVING ACTIVITIES** | ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** |

**Outcomes**

**Upon completion of the course, the students will be able to:**

**CO 1:** Develop linear regulators.

**CO 2:** Express the Line and Load Transient systems

**CO 3:** Identify the methods of determining Poles and Zeros after Miller Compensation.

**CO 4:** Investigate the PWM Control Techniques.

**CO 5:** Select small-signal modeling of a DC-DC Converter.

**Text Books**

1. ke-horn chen IEEE press"Power Management Techniques for Integrated Circuit Design" wiley publications(2016)
2. Mona M. HellaPatrick Mercier "Power Management Integrated Circuits "CRC Press.

CO Vs PO Mapping and CO Vs PSO Mapping

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 2 | 2 | | | | | | | 3 | |
| 2 | 2 | 3 | 2 | 2 | | | | | | | | 2 |
| 3 | 1 | 1 | 2 | 2 | | | | | | | 2 | |
| 4 | 2 | 1 | 2 | 2 | 3 | | | | 2 | | | 3 |
| 5 | 2 | 1 | 3 | 2 | | | | | 2 | | | |

| Course Code | HIGH VOLTAGE DIRECT CURRENT TRANSMISSION | L | T | P | C |
|---|---|---|---|---|---|
| 21PS3701 | | 3 | 0 | 0 | 3 |

**Prerequisites for the course**

- Power Electronics
- Power Generation Systems
- Power systems Analysis
- Power system operation and control

**Objectives**

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

| UNIT I | DC POWER TRANSMISSION TECHNOLOGY | 9 |
|---|---|---|

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

| UNIT II | THYRISTOR BASED HVDC CONVERTERS AND HVDC SYSTEM CONTROL | 9 |
|---|---|---|

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

| **UNIT III** | **MULTITERMINAL DC SYSTEMS** | **9** |
|---|---|---|
| Introduction – Potential applications of MTDC systems - Types of MTDC systems – Control and protection of MTDC systems - Study of MTDC systems. | | |
| **UNIT IV** | **POWER FLOW ANALYSIS IN AC/DC SYSTEMS** | **9** |
| Per unit system for DC Quantities - Modeling of DC links - Solution of DC load flow - Solution of AC-DC power flow – Unified, Sequential and Substitution of power injection method. | | |
| **UNIT V** | **SIMULATION OF HVDC SYSTEMS** | **9** |
| Introduction – DC LINK Modelling, Converter Modeling and State Space Analysis, Philosophy and tools – HVDC system simulation, Online and OFF line simulators –– Dynamic interactions between DC and AC systems. | | |
| | **Total Periods** | **45** |

| **Suggestive Assessment Methods** | | |
|---|---|---|
| **Continuous Assessment Test (30 Marks)** | **Formative Assessment Test (10 Marks)** | **End Semester Exams (60 Marks)** |
| ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** | *1.**ASSIGNMENT***<br>***2. ONLINE QUIZZES***<br>***3.PROBLEM-SOLVING ACTIVITIES*** | ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** |

**Outcomes**

**Upon completion of the course, the students will be able to:**

**CO 1:** Understand knowledge on operation, modeling and control of HVDC link

**CO 2:** Understand knowledge on thyristor based HVDC converters

**CO 3:** Understand knowledge on multi terminal DC systems

**CO 4:** Understand knowledge on power flow analysis in AC/DC systems

**CO 5 :** Expose various HVDC simulators.

**Reference Books**

1. P. Kundur, “Power System Stability and Control”, McGraw-Hill, 1993
2. K.R.Padiyar, , “HVDC Power Transmission Systems”, New Age International (P) Ltd., New Delhi, 2002
3. J.Arrillaga, , “High Voltage Direct Current Transmission”, Peter Pregrinus, London, 1983
4. rich Uhlmann, “ Power Transmission by Direct Current”, BS Publications, 2004.
5. V.K.Sood,HVDC and FACTS controllers – Applications of Static Converters in Power System, APRIL 2004 , Kluwer Academic Publishers

**Web Recourses**

- https://www.cet.edu.in/noticefiles/229_HVDC_NOTE.pdf
- https://nptel.ac.in/content/syllabus_pdf/108104013.pdf

CO Vs PO Mapping and CO Vs PSO Mapping

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | | | | | | | | | 3 | | 3 |
| 2 | 2 | | | | | | | | | 3 | | 3 |
| 3 | 2 | | | | | | | | | 3 | 2 | |
| 4 | 2 | | | | | | | | | 3 | | 3 |
| 5 | 2 | | 2 | | 2 | | | 2 | | 3 | | 2 |

| Course Code | SCADA | L | T | P | C |
|---|---|---|---|---|---|
| 21PS3702 | | 3 | 0 | 0 | 3 |

**Prerequisites for the course**

- Power System Analysis
- Measurements & Instrumentation
- Power System Operation Control

**Objectives**

1. To impart the basic building blocks of SCADA system.
2. To learn about the role of PLC as RTU in SCADA system.
3. To develop the hardware and firmware requirements of SCADA Systems.
4. To understand the communication protocols of SCADA system.
5. To understand the troubleshooting mechanisms of SCADA System

| UNIT I | SCADA SYSTEMS- HARDWARE AND FIRMWARE | 9 |
|---|---|---|

Principles of SCADA system - Remote terminal units - Application programs- PLCs used as RTUs - The master station - System reliability and availability - Communication architectures - Typical considerations in configuration of a master station.

| UNIT II | SCADA SYSTEMS - SOFTWARE AND PROTOCOLS | 9 |
|---|---|---|

The SCADA software package - Specialized SCADA protocols - Error detection – Distributed network protocol - New technologies in SCADA systems.

| **UNIT III** | **LANDLINES AND LOCAL AREA NETWORK SYSTEMS** | **9** |
|---|---|---|
| Sources of interference and noise on cables - Practical methods of reducing noise and interference on cables - Network topologies - Media access methods - IEEE 802.3 Ethernet - MAC frame format - High-speed Ethernet systems - 100Base-T (100Base-TX, T4, FX, T2) - Fast Ethernet design considerations - Gigabit Ethernet 1000Base-T - Network interconnection components - TCP/IP protocols | | |
| **UNIT IV** | **MODEMS** | **9** |
| The RS-232/RS-422/RS-485 interface standards - Flow control - Modulation techniques – Error detection/correction and data compression - Modem standards. | | |
| **UNIT V** | **CENTRAL SITE COMPUTER FACILITIES AND TROUBLESHOOTING** | **9** |
| Recommended installation practice - Ergonomic requirements - Design of the computer displays - Alarming and reporting - Troubleshooting the telemetry system | | |
| | **Total Periods** | **45** |

**Suggestive Assessment Methods**

| **Continuous Assessment Test (30 Marks)** | **Formative Assessment Test (10 Marks)** | **End Semester Exams (60 Marks)** |
|---|---|---|
| ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** | **1.ASSIGNMENT**<br>**2. ONLINE QUIZZES**<br>**3.PROBLEM-SOLVING ACTIVITIES** | ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** |

**Outcomes**

**Upon completion of the course, the students will be able to:**

**CO 1:** Explain the basic building blocks of SCADA system.

**CO 2:** Illustrate the role of PLC as RTU in SCADA system.

**CO 3:** Describe the hardware and firmware requirements of SCADA Systems.

**CO 4:** Explain the communication protocols of SCADA system.

**CO 5:** Outline the troubleshooting mechanisms of SCADA System.

**Reference Books**

1. David Bailey, Edwin Wright, "Practical SCADA for Industry", Newnes, An imprint of Elsevier 2006.
2. Gordon Clarke, Deon Reynders, Edwin Wright "Practical Modern SCADA Protocols: DNP3, 60870.5 and Related Systems", Newnes, An imprint of Elsevier 2004.

**Web Recourses**

- https://www.eit.edu.au/cms/images/Webinar_Slides/03_SK_Chapter-01_r4.pdf

CO Vs PO Mapping and CO Vs PSO Mapping

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3 | 3 | 2 | | | | | | | | 2 | |
| 2 | 3 | 2 | 2 | | 2 | | | | | | | 3 |
| 3 | 3 | 2 | 2 | 2 | 2 | | | | | | 2 | |
| 4 | 3 | 2 | 2 | | 2 | | | | | | | 3 |
| 5 | 3 | 2 | 2 | | 2 | | | | | | | 3 |

| Course Code 21PE3702 | WIND ENERGY TECHNOLOGIES | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Prerequisites for the course**

- Power Electronics for Renewable Energy Systems

**Objectives**

1. To learn the basic concepts of Wind energy conversion system.
2. To Introduce the concepts of mathematical modelling and control of the Wind turbine
3. To Acquire knowledge ondesign of Fixed speed system.
4. To impart knowledge on Variable speed system and its modelling.
5. To learn about Grid integration issues and current practices of wind interconnections with power system

| UNIT I | INTRODUCTION | 9 |
|---|---|---|

Components of WECS-WECS schemes-Power obtained from wind-simple momentum theory-Power coefficient-Sabinin's theory-Aerodynamic Principles – Design – Betz limit.

| UNIT II | WIND TURBINES | 9 |
|---|---|---|

HAWT- VAWT -Power developed- Thrust- Efficiency- Rotor selection-Rotor design considerations- Tip speed ratio-No. of Blades-Blade profile-Power Regulation-yaw control-Pitch angle control- stall control-Electrical braking – mechanical braking-MPPT Schemes.

| **UNIT III** | **FIXED SPEED SYSTEMS** | **9** |
|---|---|---|

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

| **UNIT IV** | **VARIABLE SPEED SYSTEMS** | **9** |
|---|---|---|

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

| **UNIT V** | **GRID CONNECTED SYSTEMS** | **9** |
|---|---|---|

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

| | **Total Periods** | **45** |
|---|---|---|

**Suggestive Assessment Methods**

| **Continuous Assessment Test (30 Marks)** | **Formative Assessment Test (10 Marks)** | **End Semester Exams (60 Marks)** |
|---|---|---|
| ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** | *1.**ASSIGNMENT***<br>***2. ONLINE QUIZZES***<br>***3.PROBLEM-SOLVING ACTIVITIES*** | ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** |

**Outcomes**

**Upon completion of the course, the students will be able to:**

**CO 1:** Acquire knowledge on the basic concepts of Wind energy conversion system

**CO 2:** Understand the mathematical modelling and control of the Wind turbine

**CO 3:** Develop more understanding on the design of Fixed speed system

**CO 4:** Study about the need of Variable speed system and its modelling.

**CO 5:** Able to learn about Grid integration issues and current practices of wind interconnections with power system.

**Reference Books**


1. L.L.Freris "Wind Energy conversion Systems", Prentice Hall, 1990
2. S.N.Bhadra, D.Kastha ,S.Banerjee, "Wind Electrical Systems", Oxford UniversityPress,2010.
3. Ion Boldea, "Variable speed generators", Taylor & Francis group, 2006.
4. E.W.Golding "The generation of Electricity by wind power", Redwood burnLtd.,Trowbridge,1976.
5. N. Jenkins," Wind Energy Technology" John Wiley & Sons,1997
6. S.Heir "Grid Integration of WECS", Wiley 1998.


**Web Recourses**

1. https://nptel.ac.in/content/storage2/courses/108108078/pdf/chap6/teach_slides06.pdf
2. https://nptel.ac.in/courses/108/105/108105058/

CO Vs PO Mapping and CO Vs PSO Mapping

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **2** | **2** | **1** | **3** | **2** | | **3** | **2** | | | 3 | |
| 2 | **2** | **2** | **1** | **3** | **2** | | **3** | **2** | | | | 2 |
| 3 | **2** | **2** | **1** | **3** | **2** | | **3** | **2** | | | 3 | |
| 4 | **2** | **2** | **1** | **3** | **2** | | **3** | **2** | | | | 2 |
| 5 | **2** | **2** | **1** | **3** | **2** | | **3** | **2** | | | 3 | |

| Course Code | ELECTRICAL TRANSIENTS IN POWER SYSTEMS | L | T | P | C |
|---|---|---|---|---|---|
| 21PS3703 | | 3 | 1 | 0 | 4 |

**Prerequisites for the course**

- Transmission and Distribution
- Electrical Transients
- Power System Analysis
- Power Quality

**Objectives**

1. To impart the concepts of traveling waves and propagation.
2. To learn about modeling and computational aspects transient's computation
3. To develop the techniques related to transition points in overhead transmission lines.
4. To understand the parameters and modeling of underground cables.
5. To understand the modeling of power system for transient over voltages using Electromagnetic Transient Program (EMTP).

| **UNIT I** | **TRAVELLING WAVES ON TRANSMISSION LINE** | **9** |
|---|---|---|
| Lumped and Distributed Parameters – Wave Equation – Reflection - Reflection of Travelling Waves against Transformer-and-Generator-windings, Refraction, Behaviour of Travelling waves at the line terminations – Lattice Diagrams – Attenuation and Distortion. | | |
| **UNIT II** | **LIGHTNING, SWITCHING AND TEMPORARY OVERVOLTAGES** | **9** |
| Lightning: Physical phenomena of lightning – Interaction between lightning and power system – Factors contributing to line design – Simple and Abnormal Switching Transients – Transients in three phase circuits – Very Fast Transient Over voltage (VFTO) – IEC standards and wave models. | | |
| **UNIT III** | **PARAMETERS AND MODELING OF OVERHEAD LINES** | **9** |
| Review of line parameters for simple configurations: series resistance, inductance and shunt capacitance; bundle conductors : equivalent GMR and equivalent radius; modal propagation in transmission lines: modes on multi-phase transposed transmission lines, α-β-0 transformation and symmetrical components transformation, modal impedances; analysis of modes on untransposed lines; effect of ground return and skin effect; transposition schemes. Introduction to frequency-dependent line modeling. | | |
| **UNIT IV** | **PARAMETERS AND MODELING OF UNDERGROUND CABLES** | **9** |
| Distinguishing features of underground cables: technical features, electrical parameters, overhead lines versus underground cables; cable types; series impedance and shunt admittance of single-core self-contained cables, impedance and admittance matrices for three phase system formed by three single-core self-contained cables; approximate formulas for cable parameters. | | |
| **UNIT V** | **COMPUTATION OF POWER SYSTEM TRANSIENTS** | **9** |
| Principle of digital computation – Matrix method of solution, Modal analysis, Z transforms, Computation using EMTP – Simulation of switches and non-linear elements. | | |
| | **Total Periods** | **45** |

**Suggestive Assessment Methods**

| **Continuous Assessment Test (30 Marks)** | **Formative Assessment Test (10 Marks)** | **End Semester Exams (60 Marks)** |
|---|---|---|
| ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** | **1.ASSIGNMENT**<br>**2. ONLINE QUIZZES**<br>**3.PROBLEM-SOLVING ACTIVITIES** | ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** |

**Outcomes**

**Upon completion of the course, the students will be able to:**

**CO 1:** Analyze the electrical transients in power systems.

**CO 2:** Able to analyze power system transients.

**CO 3:** Develop the techniques related to transition points in transmission lines

**CO 4:** Able to modelling of underground cables.

**CO 5:** Able to modeling of power system for transient over voltages and Familiarize in using Electromagnetic Transient Program

**Reference Books**

1. Allan Greenwood, "Electrical Transients in Power System", Wiley & Sons Inc. New York, 1991.
2. R. Ramanujam, "Computational Electromagnetic Transients: Modeling, Solution Methods and Simulation", I.K. International Publishing House Pvt. Ltd, New Delhi, 2014.
3. Naidu M S and Kamaraju V, "High Voltage Engineering", Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004
4. "Power System Transients: A Statistical Approach", by C.S Indulkar, D.P. Kothari, K. Ramalingam, PHI, 2 edition, 2010.

**Web Recourses**

1. https://onlinelibrary.wiley.com/doi/10.1002/9781118694190.ch1
2. http://www.srmvalliammai.ac.in/questionbank-meps.html
3. https://epd.wisc.edu/courses/analysis-of-transients-in-power-systems/

CO Vs PO Mapping and CO Vs PSO Mapping

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3 | 2 | | | | | | | | | | 2 |
| 2 | 2 | 3 | | | | | | | | | 3 | |
| 3 | 3 | 2 | 3 | | 2 | | | | | | | 2 |
| 4 | 2 | 2 | 3 | | 3 | | | | 2 | | 3 | |
| 5 | 2 | 3 | 3 | | 3 | | | | 2 | | | 2 |

| Course Code<br>21PE3704 | HYBRID ELECTRIC VEHICLES | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Prerequisites for the course**

- Electrical Machines-I
- Electrical machines-II
- Electric Circuit Analysis

**Objectives**

1. To present a comprehensive overview of fundamentals in hybrid electric, hybrid hydraulic and electric vehicle engineering .
2. To design HEV based on the requirements to power flow management and power conversion.
3. To impart the knowledge about the electrical machines that can be used for the e-vehicles
4. To know the design of batteries and energy storages and vehicle power electronics.
5. To design mechatronic wheel-electric drive, suspension and locomotion System.

| UNIT I | HISTORY OVERVIEW AND MODERN APPLICATIONS | 9 |
|---|---|---|

Ground vehicles with mechanical powertrain and reasons for HEV development , HEV configurations and ground vehicle applications , Advantages and challenges in HEV design, Components, vehicle mechanics – Roadway fundamentals, vehicle kinetics, Dynamics of vehicle motion - Propulsion System Design.

| UNIT II | POWER FLOW AND POWER MANAGEMENT STRATEGIES IN HEV | 9 |
|---|---|---|

Mechanical power: generation, storage and transmission to the wheels -Electric power: generation, storage and conversion to mechanical power - Hydraulic power: generation, storage and conversion to mechanical power-Energy storage/conversion and thermodynamic relations, Basics of Batteries – Types, Parameters – Capacity, Discharge rate, State of charge, state of Discharge, Depth of Discharge, Technical characteristics, Battery pack Design, Properties of Batteries.

| UNIT III | DC & AC ELECTRICAL MACHINES | 9 |
|---|---|---|

Motor and Engine rating, Requirements, DC machines, Three phase A/c machines, Induction machines, permanent magnet machines, switched reluctance machines.

| UNIT IV | POWER ELECTRONICS IN HYBRID ELECTRIC VEHICLES | 9 |
|---|---|---|

Rectifiers,Buck convertor ,Voltage source inverter ,Current source inverter , DC-DC convertor,Transmission configuration, Components – gears, differential, clutch, brakes regenerative braking, motor sizing.

| **UNIT V** | **VEHICLE DYNAMICS FUNDAMENTALS FOR HEV MODELING** | **9** |
|---|---|---|

Various strategies for improving vehicle energy/fuel efficiency -Vehicle chassis mathematical model in various operation conditions (steady motion, acceleration, regenerating braking, coasting, moving up and down a hill)-Types – series, parallel and series, parallel configuration – Design – Drive train, sizing of components.

| | |
|---|---|
| **Total Periods** | **45** |

**Suggestive Assessment Methods**

| **Continuous Assessment Test (30 Marks)** | **Formative Assessment Test (10 Marks)** | **End Semester Exams (60 Marks)** |
|---|---|---|
| ***1. DESCRIPTION QUESTIONS<br>2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** | ***1.ASSIGNMENT<br>2. ONLINE QUIZZES<br>3.PROBLEM-SOLVING ACTIVITIES*** | ***1. DESCRIPTION QUESTIONS<br>2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** |

**Outcomes**

**Upon completion of the course, the students will be able to:**

**CO 1:** Ability to choose a suitable drive scheme for developing an electric hybrid vehicle depending on resources

**CO 2:** Ability to design and develop basic schemes of electric vehicles and hybrid electric vehicles

**CO 3:** Complete knowledge about the electrical machines that can be used for the e-vehicles

**CO 4:** Ability to design the drive for the e-vehicles.

**CO 5:** Choose proper energy storage systems for vehicle applications.

**Text Books**

1. Iqbal Hussain, "Electric & Hybrid Vehicles – Design Fundamentals", Second Edition, CRC Press, 2011.

**2.** James Larminie, "Electric Vehicle Technology Explained", John Wiley & Sons, 2003.

**Reference Books**

1. MehrdadEhsani, YiminGao, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals", CRC Press, 2010.
2. Sandeep Dhameja, "Electric Vehicle Battery Systems", Newnes, 2000

**Web Recourses**

- https://nptel.ac.in/courses/108102121/

CO Vs PO Mapping and CO Vs PSO Mapping

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | | 1 | | | | | 1 | | 1 | 3 | |
| 2 | 1 | 2 | 1 | | 1 | | | 2 | | 2 | | 2 |
| 3 | 2 | | 2 | | 2 | | | 3 | | 2 | 2 | |
| 4 | 2 | | 2 | | | | | 3 | | 3 | | 3 |
| 5 | 3 | | 3 | | | | | 3 | | 3 | 2 | |

| Course Code | PRINCIPLES OF ELECTRIC POWER TRANSMISSION | L | T | P | C |
|---|---|---|---|---|---|
| 21PS3704 | | 3 | 0 | 0 | 3 |

**Prerequisites for the course**

- Power System

**Objectives**

1. To understand the modelling of transmission lines
2. To introduce the voltage gradients and losses
3. To impart knowledge on the design of EHVAC and DC transmission lines
4. To introduce estimation of the electrostatic field
5. To introduce the calculation of the HVDC line parameters.

| UNIT I | INTRODUCTION | 9 |
|---|---|---|

Standard transmission voltages-AC and DC – different line configurations– average values of line parameters – power handling capacity and line loss – costs of transmission lines and equipment – mechanical considerations in line performance.

| UNIT II | CALCULATION OF LINE PARAMETERS | 9 |
|---|---|---|

Calculation of resistance, inductance and capacitance for multi-conductor lines – calculation of sequence inductances and capacitances – line parameters for different modes of propagation – effect of ground return.

| UNIT III | VOLTAGE GRADIENTS OF CONDUCTORS | 9 |
|---|---|---|

Charge-potential relations for multi-conductor lines – surface voltage gradient on conductors – gradient factors and their use – distribution of voltage gradient on sub conductors of bundle - voltage gradients on conductors in the presence of ground wires on towers-I2R loss and corona loss-RIV.

| **UNIT IV** | **ELECTROSTATIC FIELD AND DESIGN OF EHV LINES** | **9** |
|---|---|---|
| Effect of EHV line on heavy vehicles - calculation of electrostatic field of AC lines- effect of high field on humans, animals, and plants - measurement of electrostatic fields – electrostatic Induction in unexercised circuit of a D/C line - induced voltages in insulated ground wires - electromagnetic interference, Design of EHV lines. | | |
| **UNIT V** | **HVDC LINES** | **9** |
| Introduction- Reliability and failure issues-Design-tower, ROW, clearances, insulators, electrical and mechanical protection-Maintenance-Control and protection-D.C Electric field and Magnetic field -Regulations and guide lines-underground line design. | | |
| | **Total Periods** | **45** |

**Suggestive Assessment Methods**

| **Continuous Assessment Test (30 Marks)** | **Formative Assessment Test (10 Marks)** | **End Semester Exams (60 Marks)** |
|---|---|---|
| ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** | ***1.ASSIGNMENT***<br>***2. ONLINE QUIZZES***<br>***3.PROBLEM-SOLVING ACTIVITIES*** | ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** |

**Outcomes**

**Upon completion of the course, the students will be able to:**

**CO 1:** To model the transmission lines

**CO 2:** To develop and estimate the voltage gradients and losses in transmission lines

**CO 3:** To understand and design the EHVAC and DC transmission lines

**CO 4:** To understand and estimate the electrostatic field of EHV transmission lines

**CO 5 :** To understand and evaluate the HVDC transmission line parameters

**Text Books**

1. Rakosh Das Begamudre, "Extra High Voltage AC Transmission Engineering", Second Edition, New Age International Pvt. Ltd., 2006.
2. PritindraChowdhari, "Electromagnetic transients in Power System", John Wiley and Sons Inc., 2009.
3. Sunil S.Rao, "EHV-AC, HVDC Transmission & Distribution Engineering", Third Edition, Khanna Publishers, 2008.

**Reference Books**

1. William H. Bailey, Deborah E. Weil and James R. Stewart, "A Review on HVDC Power Transmission Environmental Issues", Oak Ridge National Laboratory.
2. J.C Molburg, J.A. Kavicky, and K.C. Picel ,"A report on The design, Construction and operation of Long-distance High-Voltage Electricity Transmission Technologies" Argonne (National Laboratory) 2007.

**3.** "Power Engineer's Handbook", Revised and Enlarged 6th Edition, TNEB Engineers' Association, October 2002.

**Web Recourses**

- https://nptel.ac.in/courses/108/102/108102047/
- https://www.ijert.org/a-survey-paper-on-extra-high-voltage-ac-transmission-lines
- https://www.sciencedirect.com/topics/engineering/uhv-power-transmission

CO Vs PO Mapping and CO Vs PSO Mapping

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | - | - | - | - | 1 | - | 1 | | |
| 2 | 1 | 2 | 1 | - | 1 | - | - | 2 | - | 1 | | |
| 3 | 2 | 2 | 2 | - | 2 | - | - | 3 | - | 2 | | |
| 4 | 3 | 2 | 3 | - | 1 | - | - | 3 | - | 2 | | |
| 5 | 3 | 1 | 3 | - | - | - | - | 1 | - | 3 | | |

| Course Code | MEMS TECHNOLOGY | L | T | P | C |
|---|---|---|---|---|---|
| 21PE3707 | | 3 | 0 | 0 | 3 |

**Prerequisites for the course**

- Engineering Physics
- Measurements and Instrumentation

**Objectives**

1. To teach the students properties of materials, microstructure and fabrication methods.
2. To teach the design and modeling of Electrostatic sensors and actuators.
3. To teach the characterizing thermal sensors and actuators through design and modelling.
4. To teach the fundamentals of piezoelectric sensors and actuators through exposure to different MEMS and NEMS devices.
5. To involve Discussions/ Practice/Exercise onto revising & familiarizing the concepts acquired over the 5 Units of the subject for improved employability skills.

| UNIT I | MICRO-FABRICATION, MATERIALS AND ELECTRO-MECHANICAL CONCEPTS | 9 |
|---|---|---|

Overview of micro fabrication – Silicon and other material based fabrication processes – Concepts: Conductivity of semiconductors-Crystal planes and orientation-stress and strain-flexural beam bending analysis-torsional deflections-Intrinsic stress- resonant frequency and quality factor.

| | | |
|---|---|---|
| **UNIT II** | **ELECTROSTATIC SENSORS AND ACTUATION** | **9** |
| Principle, material, design and fabrication of parallel plate capacitors as electrostatic sensors and actuators-Applications. | | |
| **UNIT III** | **THERMAL SENSING AND ACTUATION** | **9** |
| Principle, materinal, design and fabrication of thermal couples, thermal bimorph sensors, thermal resistor sensors-Applicatios. | | |
| **UNIT IV** | **PIEZOELECTRIC SENSING AND ACTUATION** | **9** |
| Piezoelectric effect-cantilever piezoelectric actuator model-properties of piezoelectric materials-Applications. | | |
| **UNIT V** | **CASE STUDIES** | **9** |
| Piezoresistive sensors, Magnetic actuation, Micro fluidics applications, Medical applications, Optical MEMS.-NEMS Devices Note: Class room discussions and tutorials can include the following guidelines for improved teaching /learning process: Discussions/Exercise/Practice on Workbench: on the basics /device model design aspects of thermal/peizo/resistive sensors etc. | | |
| | **Total Periods** | **45** |

**Suggestive Assessment Methods**

| **Continuous Assessment Test (30 Marks)** | **Formative Assessment Test (10 Marks)** | **End Semester Exams (60 Marks)** |
|---|---|---|
| ***1. DESCRIPTION QUESTIONS<br>2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** | ***1.ASSIGNMENT<br>2. ONLINE QUIZZES<br>3.PROBLEM-SOLVING ACTIVITIES*** | ***1. DESCRIPTION QUESTIONS<br>2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** |

**Outcomes**

**Upon completion of the course, the students will be able to:**

**CO 1:** Understand basics of micro fabrication develop models and simulate electrostatic and electromagnetic sensors and actuators.

**CO 2:** Understand material properties important for MEMS system performance, analyze dynamics of resonant micromechanical structures

**CO 3:** The learning process delivers insight onto design of micro sensors, embedded sensors &actuators in power aware systems like grid.

**CO 4:** Understand the design process and validation for MEMS devices and systems, and learn the state of the art in Piezoelectric systems.

**CO 5:** Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded systems design.

**Reference Books**

1. Chang Liu, "Foundations of MEMS", Pearson International Edition, 2006.
2. Marc Madou , "Fundamentals of microfabrication",CRC Press, 1997.
3. Boston , "Micromachined Transducers Sourcebook",WCB McGraw Hill, 1998.
4. M.H.Bao "Micromechanical transducers :Pressure sensors, accelerometers and gyroscopes", Elsevier, Newyork, 2000.

**Web Recourses**

1. https://www.mems-exchange.org/MEMS/what-is.html
2. https://nptel.ac.in/courses/108108113/

CO Vs PO Mapping and CO Vs PSO Mapping

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | 3 | 1 | 2 | | | 2 | | 2 | | 1 |
| 2 | | | 3 | 1 | 2 | | | 2 | | 2 | 3 | |
| 3 | | | 3 | 1 | 2 | | | 2 | | 2 | | 2 |
| 4 | | | 3 | 1 | | | | 2 | | 2 | 3 | |
| 5 | | | 3 | | 2 | | | 2 | | 2 | 3 | |

| Course Code | ADVANCED POWER SYSTEM DYNAMICS | L | T | P | C |
|---|---|---|---|---|---|
| 21PS3705 | | 3 | 0 | 0 | 3 |

**Prerequisites for the course**

- Transmission system
- Power system Analysis
- Power system operation and control

**Objectives**

1. To perform review of classical methods
2. To impart knowledge on unified algorithm.
3. To familiarize the concepts of PSS.
4. To analyze voltage stability problem in power system.
5. To familiarize the model of synchronous machine.

| **UNIT I** | **REVIEW OF CLASSICAL METHODS** | **9** |
|---|---|---|
| System model, states of operation and system security, steady state stability, transient stability, simple representation of excitation control. | | |
| **UNIT II** | **UNIFIED ALGORITHM FOR DYNAMIC SYSTEM ANALYSIS** | **9** |
| Need for unified algorithm- numerical integration algorithmic steps-truncation error- variable step size – handling the discontinuities- numerical stability- application of the algorithm for transient. Mid-term and long-term stability simulations. | | |
| **UNIT III** | **POWER SYSTEM STABILIZERS** | **9** |
| Basic concepts of control signals in PSS-Structure and tuning-Field implementation- PSS design and application-future trends. | | |
| **UNIT IV** | **VOLTAGE STABILITY ANALYSIS** | **9** |
| Review of transmission aspects – Generation Aspects: Review of synchronous machine theory – Voltage and frequency controllers – Limiting devices affecting voltage stability – Voltage-reactive power characteristics of synchronous generators – Capability curves – Effect of machine limitation on deliverable power – Load Aspects – Voltage dependence of loads – Load restoration dynamics – Induction motors – Load tap changers – Thermostatic load recovery – General aggregate load models. | | |
| **UNIT V** | **DYNAMICS OF SYNCHRONOUS GENERATOR** | **9** |
| System model, simplified synchronous machine model, calculation of Initial conditions, system simulation, improved model of synchronous machine, inclusion of SVC model. | | |
| | **Total Periods** | **45** |

**Suggestive Assessment Methods**

| **Continuous Assessment Test (30 Marks)** | **Formative Assessment Test (10 Marks)** | **End Semester Exams (60 Marks)** |
|---|---|---|
| ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** | **1.ASSIGNMENT**<br>**2. ONLINE QUIZZES**<br>**3.PROBLEM-SOLVING ACTIVITIES** | ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** |

**Outcomes**

**Upon completion of the course, the students will be able to:**

**CO 1:** Learners will be able to understand the transient stability analysis.

**CO 2:** Learners will have knowledge on unified algorithm for dynamic analysis of power systems

**CO 3:** Learners will have knowledge on field implementation of PSS.

**CO 4:** Learners will understand the concepts load aspects of voltage stability analysis

**CO 5:** Learners will attain basic knowledge on transient stability and counter measures for synchronous model

**Text Books**

1. R.Ramnujam," Power System Dynamics Analysis and Simulation", PHI Learning Private Limited, New Delhi, 2009
2. T.V. Cutsem and C.Vournas, "Voltage Stability of Electric Power Systems", Kluwer publishers,1998
3. P. Kundur, "Power System Stability and Control", McGraw-Hill, 1993.
4. H.W. Dommel and N.Sato, "Fast Transient Stability Solutions," IEEE Trans., Vol. PAS-91, pp, 1643-1650, July/August 1972.

**Reference Books**

1. Roderick J .Frowd and J. C. Giri, "Transient stability and Long term dynamics unified", IEEE Trans., Vol 101, No. 10, October 1982.
2. M.Stubbe, A.Bihain,J.Deuse, J.C.Baader, "A New Unified software program for the study of the dynamic behaviour of electrical power system" IEEE Transaction, Power Systems, Vol.4.No.1,Feb:1989 Pg.129 to 138

**Web Recourses**

1. https://arxiv.org/ftp/arxiv/papers/1808/1808.03705.pdf
2. https://link.springer.com/chapter/10.1007/978-1-4615-4561-3_7
3. https://www.eeeguide.com/dynamics-of-synchronous-machine

CO Vs PO Mapping and CO Vs PSO Mapping

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | | 2 | | | | | | | 3 | | 2 |
| 2 | 2 | | | | 2 | | | 3 | | 3 | | 3 |
| 3 | 2 | | 2 | | | | | 3 | | 3 | 2 | |
| 4 | 2 | | | | | | | | | 3 | | 3 |
| 5 | 2 | | 2 | | | | | | | 3 | 2 | |

| Course Code 21PS3706 | DESIGN OF SUBSTATIONS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Prerequisites for the course**

- Engineering Physics
- Transmission and Distribution

**Objectives**

1. To familiarize the methods of transient stability enhancement.
2. To provide in-depth knowledge on design criteria of Air Insulated Substation (AIS) and Gas Insulated Substation (GIS).
3. To study the substation insulation co-ordination and protection scheme.
4. To study the source and effect of fast transients in AIS and GISTo develop maximum power point tracking algorithms.

| UNIT I | INTRODUCTION TO AIS AND GIS | 9 |
|---|---|---|

Introduction – characteristics – comparison of Air Insulated Substation (AIS) and Gas Insulated Substation (GIS) – main features of substations, Environmental considerations, Planning and installation- GIB / GIL.

| UNIT II | MAJOR EQUIPMENT AND LAYOUT OF AIS AND GIS | 9 |
|---|---|---|

Major equipment – design features – equipment specification, types of electrical stresses, mechanical aspects of substation design- substation switching schemes- single feeder circuits; single or main bus and sectionalized single bus- double main bus-main and transfer bus- main, reserve and transfer bus- breaker-and-a- half scheme-ring bus.

| UNIT III | INSULATION COORDINATION OF AIS AND GIS | 9 |
|---|---|---|

Introduction – stress at the equipment – insulation strength and its selection – standard BILs – Application of simplified method – Comparison with IEEE and IEC guides.

| UNIT IV | GROUNDING AND SHIELDING | 9 |
|---|---|---|

Definitions – soil resistivity measurement – ground fault currents – ground conductor – design of substation grounding system – shielding of substations – Shielding by wires and masts

| UNIT V | FAST TRANSIENTS PHENOMENON IN AIS AND GIS | 9 |
|---|---|---|

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

| | Total Periods | 45 |
|---|---|---|

| **Suggestive Assessment Methods** | | |
|---|---|---|
| **Continuous Assessment Test (30 Marks)** | **Formative Assessment Test (10 Marks)** | **End Semester Exams (60 Marks)** |
| ***1. DESCRIPTION QUESTIONS 2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** | ***1.ASSIGNMENT 2. ONLINE QUIZZES 3.PROBLEM-SOLVING ACTIVITIES*** | ***1. DESCRIPTION QUESTIONS 2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** |

**Outcomes**

**Upon completion of the course, the students will be able to:**

**CO 1:** Able to apply Awareness towards substation equipment and their arrangements.

**CO 2:** Able to design the substation for present requirement with proper insulation coordination and protection against fast transients.

**CO 3:** Develop more understanding about insulation concepts

**CO 4 :** Acquire knowledge about grounding and shielding methods

**CO 5:** Understand about fast transient phenomenon in power system.

**Reference Books**


1. Andrew R. Hileman, "Insulation coordination for power systems", Taylor and Francis, 1999.
2. M.S. Naidu, "Gas Insulation Substations", I.K. International Publishing House Private Limited, 2008.
3. Klaus Ragallar, "Surges in high voltage networks" Plenum Press,New York, 1980.
4. "Power Engineer's handbook", TNEB Association.
5. PritindraChowdhuri, "Electromagnetic transients in power systems", PHI Learning Private Limited, New Delhi, Second edition, 2004.
6. "Design guide for rural substation", United States Department of Agriculture, RUS Bulletin, 1724E-300, June 2001.
7. AIEE Committee Report, "Substation One-line Diagrams," AIEE Trans. On Power Apparatus and Systems, August 1953.
8. Hermann Koch, "Gas Insulated Substations", Wiley-IEEE Press, 2014.


**Web Recourses**

1. https://nptel.ac.in/courses/108107112/
2. https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/108102047/lec23.pdf
3. https://nptel.ac.in/content/storage2/courses/108107028/module1/lecture1/lecture1.pdf

CO Vs PO Mapping and CO Vs PSO Mapping

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3 | | | | | | | 3 | 3 | 3 | | 3 |
| 2 | 3 | | 2 | | | | | | | 3 | | 2 |
| 3 | 3 | 2 | 2 | | | | | | | 3 | 2 | |
| 4 | 3 | | 2 | | | | | 2 | | 3 | | 2 |
| 5 | 3 | | | | | | | 2 | 2 | 3 | 2 | |

| Course Code 21PE3708 | POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Prerequisites for the course**

Power Electronics

**Objectives**

1. To provide knowledge about the stand alone and grid connected renewable energy systems.
2. To equip with required skills to derive the criteria for the design of power converters for renewable energy applications.
3. To analysis and comprehend the various operating modes of wind electrical generators and solar energy systems.
4. To design different power converters namely AC to DC, DC to DC and AC to ACconverters for renewable energy systems.
5. To develop maximum power point tracking algorithms.

| UNIT I | INTRODUCTION | 9 |
|---|---|---|

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

| UNIT II | ELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION | 9 |
|---|---|---|

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

| UNIT III | POWER ELECTRONICS FOR SOLAR | 9 |
|---|---|---|
| Block diagram of solar photo voltaic system : line commutated converters (inversion-mode) - Boost and buck-boost converters-selection of inverter, battery sizing, array sizing- standalone PV systems - Grid tied and grid interactive inverters- grid connection issues. | | |
| **UNIT IV** | **POWER ELECTRONICS FOR WIND** | **9** |
| Three phase AC voltage controllers-AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, matrix converters- Stand alone operation of fixed and variable speed wind energy conversion systems- Grid connection Issues -Grid integrated PMSG and SCIG Based WECS. | | |
| **UNIT V** | **HYBRID RENEWABLE ENERGY SYSTEMS** | **9** |
| Need for Hybrid Systems -Range and type of Hybrid systems-Case studies of Wind PV Maximum Power Point Tracking (MPPT) | | |
| | **Total Periods** | **45** |

**Suggestive Assessment Methods**

| **Continuous Assessment Test (30 Marks)** | **Formative Assessment Test (10 Marks)** | **End Semester Exams (60 Marks)** |
|---|---|---|
| ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** | **1.ASSIGNMENT**<br>**2. ONLINE QUIZZES**<br>**3.PROBLEM-SOLVING ACTIVITIES** | ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** |

**Outcomes**

**Upon completion of the course, the students will be able to:**

**CO 1:** Analyze the impacts of renewable energy generation on environment.

**CO 2:** Understand the importance and qualitative analysis of solar and wind energy sources.

**CO 3:** Apply the principle of operation of electrical machines for wind energy conversion and their performance characteristics.

**CO 4**: Design suitable power converters for solar PV and wind energy systems.

**CO 5:** Design suitable power for Hybrid converters

**Reference Books**

1. S.N.Bhadra, D. Kastha, & S. Banerjee "Wind Electrical Systems", Oxford UniversityPress, 2009.
2. Rashid .M. H "power electronics Hand book", Academic press, 2001.

3. Rai. G.D, "Non conventional energy sources", Khanna publishes, 1993.
4. Rai. G.D," Solar energy utilization", Khanna publishes, 1993.
5. Gray, L. Johnson, "Wind energy system", prentice hall linc, 1995.
6. B.H.Khan, " Non-conventional Energy sources", Tata McGraw-hill PublishingCompany.
7. P.S.Bimbhra,"Power Electronics",Khanna Publishers, 3rd Edition,2003.
8. Fang Lin Luo Hong Ye, " Renewable Energy systems", Taylor & Francis Group,2013.
9. R.Seyezhai and R.Ramaprabha, "Power Electronics for Renewable Energy Systems", Scitech Publications, 2015.

**Web Recourses**

1. **https://ieeexplore.ieee.org/iel5/4778359/4778360/04778368.pdf**

CO Vs PO Mapping and CO Vs PSO Mapping

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3 | | | | | | | 3 | 3 | 3 | | 3 |
| 2 | 3 | | 2 | | | | | | | 3 | 3 | |
| 3 | 3 | **2** | 2 | | | | | | | 3 | 2 | |
| 4 | 3 | | 2 | | | | | 2 | | 3 | | 2 |
| 5 | 3 | | | | | | | 2 | 2 | 3 | 2 | |

| Course Code | POWER PLANT INSTRUMENTATION AND CONTROL | L | T | P | C |
|---|---|---|---|---|---|
| 21PS3707 | | 3 | 0 | 0 | 3 |

**Prerequisites for the course**

Control Systems

**Objectives**

1. To study the concept of power generation using various resources.
2. .To understand the concept of Basics measurements involved in power generation plants.
3. To understand the Nature of the demand-Setting the demand in power stations applications.
4. To understand the concept of boilers.
5. To understand the basic concept of control equipment practice.

| **UNIT I** | **OVERVIEW OF POWER GENERATION** | **9** |
|---|---|---|
| Brief survey of methods of power generation – Hydro, thermal, nuclear, solar and wind power – Importance of instrumentation in power generation – Thermal power plants – Block diagram – Details of boiler processes - UP&I diagram of boiler – Cogeneration. | | |
| **UNIT II** | **MEASUREMENTS IN POWER PLANTS** | **9** |
| Electrical measurements – Current, voltage, power, frequency, power factor etc. – Non electrical parameters – Flow of feed water, fuel, air and steam with correction factor for temperature – Steam pressure and steam temperature – Drum level measurement – Radiation detector – Smoke density measurement – Dust monitor. | | |
| **UNIT III** | **SETTING THE DEMAND FOR THE STEAM GENERATOR** | **9** |
| Nature of the demand-Setting the demand in power stations applications-Master demand in power station applications-Load demand in combined heat and power plants-Waste to energy plants. | | |
| **UNIT IV** | **BOILER CONTROL** | **9** |
| The principles of compression control-Draught control-The principles of feed water control-One, two and three elements feed water control Drum level control-Steam temperature control-Spray-water attemperator- Temperature control with tilting burners-controlling temperature of reheated steam-Gas Recycling. | | |
| **UNIT V** | **CONTROL EQUIPMENT PRACTICE** | **9** |
| DCS configuration in power plant-A Typical DCS configuration-Interconnections between systems-Equipment selection and environment-Mechanical factors and ergonomics-Electrical actuators-Hydraulic actuators-Cabling-Electromagnetic compatibility-Reliability of systems | | |
| | **Total Periods** | **45** |

**Suggestive Assessment Methods**

| **Continuous Assessment Test (30 Marks)** | **Formative Assessment Test (10 Marks)** | **End Semester Exams (60 Marks)** |
|---|---|---|
| ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** | **1.ASSIGNMENT**<br>**2. ONLINE QUIZZES**<br>**3.PROBLEM-SOLVING ACTIVITIES** | ***1. DESCRIPTION QUESTIONS***<br>***2. FORMATIVE MULTIPLE CHOICE QUESTIONS*** |

| **Outcomes** |
|---|
| **Upon completion of the course, the students will be able to:** |
| **CO 1:** Able to apply Awareness towards substation equipment and their arrangements. |
| **CO 2:** Able to design the substation for present requirement with proper insulation coordination and protection against fast transients. |
| **CO 3:** Develop more understanding about insulation concepts |
| **CO 4:** Acquire knowledge about grounding and shielding methods |
| **CO 5:** Understand about fast transient phenomenon in power system. |
| **Text Books** |
| 1. P.K.Nag, "Power Plant Engineering" Tata McGraw-Hill, NewDelhi, 2005.<br>2. Sam G.Dukelow, The control of Boilers, Instrument Society of America, 1991. |
| **Reference Books** |
| 1. David Lindsley, "Power Plant Control & Instrumentation ",IEE Publications,London, UK (2001).<br>2. Elonka, S.M. and Kohal A.L.Standard Boiler Operations, McGraw Hill,New Delhi, 1994.<br>3. R.K.Jain, Mechanical and Industrial Measurements, Khanna Publishers, New Delhi, 1995.<br>4. Al. Wakil, 'Power Plant Engineering', Tata McGraw Hill, 1984.<br>5. A.K.Mahalanbias-"Power System Instrumentation"-Tata McGraw Hill. |

CO Vs PO Mapping and CO Vs PSO Mapping

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3 | | | | | | | 3 | 3 | 3 | | 3 |
| 2 | 3 | | 2 | | | | | | | 3 | 3 | |
| 3 | 3 | 2 | 2 | | | | | | | 3 | 2 | |
| 4 | 3 | | 2 | | | | | 2 | | 3 | | 2 |
| 5 | 3 | | | | | | | 2 | 2 | 3 | 2 | |