ANNAMALAI UNIVERSITY
Annamalainagar

FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL ENGINEERING

M.E. POWER SYSTEMS (Two-Year Full Time & Three-year Part Time) DEGREE PROGRAMME
Choice Based Credit System

HAND BOOK
2017
DEPARTMENT OF ELECTRICAL ENGINEERING

Vision - Mission Statement

Vision

Empowering the community of students of Department of Electrical Engineering with very high morals, values, ethics, skills and technical knowledge through a rich curriculum blending the equal proportions of theoretical and hands-on experience by a process of transformation via hard-work and perseverance, with a view to serving the society in the role of socially responsible engineers so as to look after the needs of the nation and to elevate the standard of living of the people by incorporating innovation and sustained research.

Mission

- To attract the students to pursue not only the under graduation, but also up to the research level, with the exquisite infrastructure, learned faculties, state-of-the-art laboratories etc., from the Indian and International diasporas.
- To foster the global standards in learning, teaching and research that owes to an overall development of the department, faculties and students within the university and from across the globe as well.
- To enhance the caliber of students to be the most sought for, by the industrial and research entities.
- To enable for a diversified and challenging career that is ensued by the highest degree of professionalism, entrepreneurship, managerial and administrative expertise.

M.E. (POWER SYSTEMS)
Programme Educational Objectives (PEO)

The core objectives of the M.E. programme in Power Systems are intended

PEO-1
To develop professional knowledge in power systems domain so as to have successful career in industries, research and academia.

PEO-2
To enhance analytical skills to solve challenging complex problems in power and energy sectors using modern tools and technologies.

PEO-3
To inculcate research attitude and lifelong learning among the students.

PEO-4
To demonstrate professional and ethical behaviour and be engaged in executing projects in multidisciplinary environment for the benefit of society.
Programme Outcomes (PO)

PO-1
Identification, Analysis and Formulation of Real-time Engineering Problems and Ability to devise Innovative Methodologies for their Effective and Efficient Tackling

PO-2
Application of Technical, Mathematical, Reasoning and Logical skills to Design and Implement Novel Systems, with a view to enhance the Standard of Living of the Society

PO-3
Evaluation and Validation upon the State-of-the-art Solution Strategies employed in Various Spheres of Electrical and Electronics Engineering

PO-4
Indulging in and Valuing the Ethical Principles, Eco-friendliness, Societal-benefits and Socio-economic concerns

PO-5
To emulate in the Research pertaining to the Fundamental and Advanced Areas of Power Systems, Power Electronics, Digital Electronics, Microprocessors/Microcontrollers etc.

PO-6
Capability to excel in Multi-disciplinary Specializations and Research in bridging the gap between the Conventional and Modern Modalities / Requirements

PO-7
Abiding by the Regulations, Norms, Standards and Rules that have been put forth by the Pioneers and Organizations of the E.E.E. Society

PO-8
Exhibition of Skills that look after Team-playing Virtues and Nurturing Leadership Qualities, especially while working in tandem with Fellow Engineers for Social Goodness

PO-9
Curiosity in developing Managerial and Administrative capabilities that aims for the betterment of Professionals and Professionalism

PO-10
Ability to engage in self-education and life-long learning to enable competence globally.

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<th>Mapping of PEO with PO</th>
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M.E. / M. Tech (Two-Year Full Time & Three-year Part Time) DEGREE PROGRAMME

CHOICE BASED CREDIT SYSTEM (CBCS) REGULATIONS

1. Condition for Admission
   Candidates for admission to the first year of the four-semester M.E / M.Tech Degree programme in Engineering shall be required to have passed B.E / B.Tech degree of Annamalai University or any other authority accepted by the syndicate of this University as equivalent thereto. They shall satisfy the condition regarding qualifying marks and physical fitness as may be prescribed by the syndicate of the Annamalai University from time to time. The admission for part time programme is restricted to those working or residing within a radius of 90 km from Annamalainagar. The application should be sent through their employers.

2. Branches of Study in M.E / M.Tech
   The Branch and Eligibility criteria of programmes are given in Annexure 1.

3. Courses of study
   The courses of study and the respective syllabi for each of the M.E / M. Tech programmes offered by the different Departments of study are given separately.

4. Scheme of Examinations
   The scheme of Examinations is given separately.

5. Choice Based Credit System (CBCS)
   The curriculum includes three components namely Professional Core, Professional Electives and Open Electives in addition to Thesis. Each semester curriculum shall normally have a blend of theory and practical courses.

6. Assignment of Credits for Courses
   Each course is normally assigned one credit per hour of lecture / tutorial per week and one credit for two hours or part thereof for laboratory or practical per week. The total credits for the programme will be 65.

7. Duration of the programme
   A student of M.E / M.Tech programme is normally expected to complete in four semesters for full-time / six semesters for part-time but in any case not more than four years for full-time / six years for part-time from the date of admission.

8. Registration for courses
   A newly admitted student will automatically be registered for all the courses prescribed for the first semester, without any option. Every other student shall submit a completed registration form indicating the list of courses intended to be credited during the next semester. This registration will be done a week before the last working day of the current semester. Late registration with the approval of the Dean on the recommendation of the Head of the Department along with a late fee will be done up to the last working day. Registration for the Thesis Phase - I and II shall be done at the appropriate semesters.
9. Electives
The student has to select two electives in first semester and another two electives in the second semester from the list of Professional Electives. The student has to select two electives in third semester from the list of Open Electives offered by the department/allied department. A student may be allowed to take up the open elective courses of third semester (Full Time program) in the first and second semester, one course in each of the semesters to enable them to carry out thesis in an industry during the entire second year of study provided they should register those courses in the first semester itself. Such students should meet the teachers offering those elective courses themselves for clarifications. No specific slots will be allotted in the time table for such courses.

Further, the two open elective courses to be studied in III semester (Full Time programme) may also be credited through the SWAYAM portal of UGC with the approval of Head of the Department concerned. In such a case, the courses must be credited before the end of III Semester.

10. Assessment
The break-up of continuous assessment and examination marks for theory courses is as follows:

First assessment (Mid-Semester Test-I) : 10 marks
Second assessment (Mid-Semester Test-II) : 10 marks
Third Assessment : 5 marks
End Semester Examination : 75 marks

The break-up of continuous assessment and examination marks for Practical courses is as follows:

First assessment (Test-I) : 15 marks
Second assessment (Test-II) : 15 marks
Maintenance of record book : 10 marks
End Semester Examination : 60 marks

The thesis Phase I will be assessed for 40 marks by a committee consisting of the Head of the Department, the guide and a minimum of two members nominated by the Head of the Department. The Head of the Department will be the chairman. The number of reviews must be a minimum of three per semester. 60 marks are allotted for the thesis work and viva voce examination at the end of the third semester. The same procedure will be adopted for thesis Phase II in the fourth semester.

11. Student Counsellors (Mentors)
To help the students in planning their course of study and for general advice on the academic programme, the Head of the Department will attach a certain number of students to a member of the faculty who shall function as student counsellor for those students throughout their period of study. Such student counsellors shall advise the students, give preliminary approval for the courses to be taken by the students during each semester, monitor their progress in SWAYAM courses/open elective courses and obtain the final approval of the Head of the Department.
12. Class Committee
For each of the semesters of M.E / M.Tech programmes, separate class committees will be constituted by the respective Head of the Departments. The composition of the class committees from first to fourth semesters for Full time and first to sixth semesters for Part-time will be as follows:

- Teachers of the individual courses.
- A Thesis coordinator (for Thesis Phase I and II) shall be appointed by the Head of the Department from among the Thesis supervisors.
- A thesis review committee chairman shall be appointed by the Head of the Department.
- One Professor or Associate Professor, preferably not teaching the concerned class, appointed as Chairman by the Head of the Department.
- The Head of the Department may opt to be a member or the Chairman.
- All counselors of the class and the Head of the Department (if not already a member) or any staff member nominated by the Head of the Department may opt to be special invitees.

The class committee shall meet three times during the semester. The first meeting will be held within two weeks from the date of class commencement in which the type of assessment like test, assignment etc. for the third assessment and the dates of completion of the assessments will be decided.

The second meeting will be held within a week after the completion of the first assessment to review the performance and for follow-up action.

The third meeting will be held after all the assessments but before the University semester examinations are completed for all the courses, and at least one week before the commencement of the examinations. During this meeting the assessment on a maximum of 25 marks for theory / 40 marks for practical and project work will be finalized for every student and tabulated and submitted to the Head of the Department for approval and transmission to the Controller of Examinations.

13. Temporary Break Of Study
A student can take a one-time temporary break of study covering the current semester and/or the next semester with the approval of the Dean on the recommendation of the Head of the Department, not later than seven days after the completion of the mid-semester test. However, the student must complete the entire programme within the maximum period of four years for Full time / six years for Part time.

14. Substitute Assessments
A student who has missed, for genuine reasons accepted by the Head of the Department, one or more of the assessments of a course other than the end of semester examination may take a substitute assessment for any one of the missed assessments. The substitute assessment must be completed before the date of the third meeting of the respective class committees.

A student who wishes to have a substitute assessment for a missed assessment must apply to the Head of the Department within a week from the date of the missed assessment.
15. Attendance Requirements
The students with 75% attendance and above are permitted to appear for the University examinations. However, the Vice Chancellor may give a rebate / concession not exceeding 10% in attendance for exceptional cases only on Medical Grounds.
A student who withdraws from or does not meet the minimum attendance requirement in a semester must re-register and repeat the same semester in the subsequent academic years.

16. Passing and declaration of Examination Results
All assessments of all the courses on an absolute marks basis will be considered and passed by the respective results passing boards in accordance with the rules of the University. Thereafter, the controller of examinations shall convert the marks for each course to the corresponding letter grade as follows, compute the grade point average (GPA) and cumulative grade point average (CGPA) and prepare the mark sheets.

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<tr>
<td>90 to 100</td>
<td>Grade ‘S’</td>
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<tr>
<td>80 to 89</td>
<td>Grade ‘A’</td>
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<td>70 to 79</td>
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<td>60 to 69</td>
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<td>Less than 50</td>
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<td>Withdrawn from the Examination</td>
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<td>Grade ‘W’</td>
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</table>

A student who obtains less than 30 / 24 marks out of 75 / 60 in the theory / practical examinations respectively or is absent for the examination will be awarded grade RA.
A student who earns a grade of S, A, B, C, D or E for a course is declared to have successfully completed that course and earned the credits for that course. Such a course cannot be repeated by the student.
A student who obtains letter grade RA / W in the mark sheet must reappear for the examination of the courses.
The following grade points are associated with each letter grade for calculating the grade point average and cumulative grade point average.

- S - 10;
- A - 9;
- B - 8;
- C - 7;
- D - 6;
- E - 5;
- RA - 0

Courses with grade RA / W are not considered for calculation of grade point average or cumulative grade point average.
A student can apply for re-totaling of one or more of his examination answer papers within a week from the date of issue of mark sheet to the student on payment of the prescribed fee per paper. The application must be made to the Controller of Examinations with the recommendation of the Head of the Department.
After the results are declared, mark sheets will be issued to the students. The mark sheet will contain the list of courses registered during the semester, the grades scored and the grade point average for the semester.

GPA is the sum of the products of the number of credits of a course with the grade point scored in that course, taken over all the courses for the semester, divided by the sum of the number of credits for all courses taken in that semester.

CGPA is similarly calculated considering all the courses taken from the time of admission.

17. Awarding Degree

After successful completion of the programme, the degree will be awarded with the following classifications based on CGPA.

For First Class with Distinction the student must earn a minimum of 65 credits within four semesters for full-time / six semesters for Part time from the time of admission, pass all the courses in the first attempt and obtain a CGPA of 8.25 or above.

For First Class, the student must earn a minimum of 65 credits within two years and six months for full-time / three years and six months for Part time from the time of admission and obtain a CGPA of 6.75 or above.

For Second class, the student must earn a minimum of 65 credits within four years for full-time / six years for Part time from the time of admission.

18. Ranking of Candidates

The candidates who are eligible to get the M.E / M.Tech degree in First Class with Distinction will be ranked on the basis of CGPA for all the courses of study from I to IV semester for M.E / M.Tech full-time / I to VI semester for M.E / M.Tech part-time.

The candidates passing with First Class and without failing in any subject from the time of admission will be ranked next to those with distinction on the basis of CGPA for all the courses of study from I to IV semester for full-time / I to VI semester for M.E / M.Tech part-time.

19. Transitory Regulations

If a candidate studying under the old regulations M.E. / M.Tech could not attend any of the courses in his/her courses, shall be permitted to attend equal number of courses, under the new regulation and will be examined on those subjects. The choice of courses will be decided by the concerned Head of the department. However he/she will be permitted to submit the thesis as per the old regulations. The results of such candidates will be passed as per old regulations.

The University shall have powers to revise or change or amend the regulations, the scheme of examinations, the courses of study and the syllabi from time to time.
## ANNEXURE 1

<table>
<thead>
<tr>
<th>No.</th>
<th>Department</th>
<th>Programme (Full Time &amp; Part time)</th>
<th>Eligible B.E./B.Tech Programme *</th>
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<td>Electronics &amp; Instrumentation Engineering</td>
<td>Electrical and Electronics Engg, Control and Instrumentation Engg, Instrumentation Engg</td>
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<td>Chemical Engineering</td>
<td>Electrical and Electronics Engg, Control and Instrumentation Engg, Instrumentation Engg</td>
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<td>i.</td>
<td>Chemical Engineering</td>
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<td>Industrial Bio Technology</td>
<td>B.E. / B.Tech - Chemical Engg, Food Technology, Biotechnology, Leather Technology</td>
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<td>iv.</td>
<td>Industrial Safety Engineering</td>
<td>B.E. / B.Tech – Any Branch of Engineering</td>
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* AMIE in the relevant discipline is considered equivalent to B.E*
### Curriculum for M.E. Power Systems (Full-Time)

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*Note: * - Four weeks during the summer vacation at the end of IIrd Semester.

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L- Lecture ; P-Practical ; T-Thesis ; CA-Continuous Assessment; FE-Final Exam
## Curriculum for M.E. Power Systems (Part-Time)

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**Semester – IV**

1. PC-VIII  PPSEC401  Power System Stability  4  -  -  25  75  100  3  PSEC204
2. PE-III   PPSEE402  Professional Elective-III  4  -  -  25  75  100  3  PSEE205
3. PE-IV    PPSEE403  Professional Elective-IV   4  -  -  25  75  100  3  PSEE206
4. PC Lab-II PPSEP404  Power System Simulation and Analysis Laboratory-II  -  -  3  40  60  100  2  PSEP207
5. Semin    PPSES405  Seminar  -  -  2  100  -  100  1  PSES208

**Total**  12  -  5  215  285  500  12

**Note:** * - Four weeks during the summer vacation at the end of IVth Semester

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**Semester – V**

1. OE-I    PPSEE501  Open Elective-I   4  -  -  25  75  100  3  PSEE301
2. OE-II   PPSEE502  Open Elective-II  4  -  -  25  75  100  3  PSEE302
3. Thesis  PPSET503  Thesis Phase-I    -  4  -  40  60  100  4  PSET303
4. Ind Train PPSET504  Industrial Training  -  *  -  100  -  100  2  PSET304

**Total**  8  4  -  190  210  400  12

**PE – PROFESSIONAL ELECTIVES**

1. FLEXIBLE AC TRANSMISSION SYSTEMS
2. SMART GRID
3. WIND AND SOLAR ENERGY SYSTEMS
4. ENERGY MANAGEMENT AND ENERGY AUDIT

L- Lecture; P-Practical; T-Thesis; CA-Continuous Assessment; FE-Final Exam
5. DISTRIBUTED GENERATION AND MICROGRIDS
6. SOLID STATE CONTROLLED ELECTRIC DRIVES
7. POWER SYSTEM DYNAMICS
8. POWER SYSTEM TRANSIENTS
9. POWER SYSTEM RELIABILITY
10. POWER QUALITY STUDIES
11. SYSTEMS THEORY
12. ELECTRICAL DISTRIBUTION SYSTEMS

OE-OPEN ELECTIVES
1. SOFT COMPUTING TECHNIQUES
2. OPTIMIZATION TECHNIQUES
3. CLOUD COMPUTING
4. SCIENTIFIC RESEARCH AND TECHNICAL COMMUNICATION
5. INTERNET OF THINGS
6. INTELLECTUAL PROPERTY RIGHTS
COURSE OBJECTIVES:

- To strengthen the mathematical background of the students
- To expose the students to the latest areas required in the field of study of power systems
- To enable the student to build up his mathematical ability in Matrices
- To acquire the knowledge in Statistics to understand the concepts with a sense of applicability
- To emphasize on the study of operations research with specified reference to quadratic programming
- To exploit the use of PDE for design analysis and simulation of power systems

Matrices

Computation of the greatest and the least Eigen values of a matrix by power method - Modal matrix and spectral matrix - Hermitian form - Canonical form.

Operations Research

Linear programming - Graphical method - Simplex method - Nonlinear programming with special reference to quadratic programming - Kuhn Tucker conditions - Dynamic programming - Bellman's principle of optimality.

Statistics

Random variables - Distribution function - Density function - Variance and covariance - Stochastic process - Auto correlation and auto covariance - Cross correlation and cross covariance - Stationary process - Auto correlation and cross correlation functions - Power spectrum.

Boundary Value Problems

Special functions and multiple Fourier series: Orthogonal functions, Bessel functions and Legendre polynomials - Generalized Fourier series expansions of an arbitrary function in terms of orthogonal functions, Bessel functions of order zero and Legendre polynomials - Fourier series expansions of functions of two and three variables.

Partial Differential Equations:

Solution of wave equation, diffusion equation, Poisson equation and Laplace equation by the method of separation of variables - Transverse vibration of rectangular and circular membranes - Potentials due to charged circular rings, circular plates and spheres.

REFERENCES:


COURSE OUTCOMES:

1. Enhance skills in Matrix operation to apply in power system domain.
2. Familiarize with Linear and nonlinear programming methods.
3. Acquire knowledge in handling situations involving random variables, random processes.
4. Able to solve some boundary value problems.
5. Acquire basic understanding of the most common partial differential equations

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COURSE OBJECTIVES:

- To introduce applications of computer in power system analysis.
- To understand the mathematical modelling of transmission line, transformer and synchronous machine.
- To study the importance of sparse matrix techniques for large scale power system.
- To impart in depth knowledge of various power flow studies in power system.
- To develop the computational algorithm to simulate balanced and unbalanced faults in power system.
- To understand the multimachine stability problem in power system.
Modelling of Power System

Elements of transmission network – overhead transmission line representation, transformer representation, synchronous machine representation - Distinction between steady state, quasi steady state and transient modelling of power system - Importance of power flow, short circuit and stability studies in the planning and operation of power system.

Sparsity Techniques


Power Flow Studies


Short Circuit Studies

Short circuit analysis of a multi-node power system using bus impedance matrix ZBUS - Building algorithm for ZBUS - Algorithm for symmetrical fault analysis using ZBUS - Development of voltage and current equations under unsymmetrical faults using symmetrical components and algorithm for unsymmetrical fault analysis using ZBUS.

Stability Studies

Mathematical model for stability analysis of multimachines - Computational algorithm for power system stability solution of swing equation - Modified Euler method and 4th order Runge-Kutta method.

REFERENCES:


COURSE OUTCOMES:

1. Acquire knowledge about the modelling of power system components.
2. Ability to introduce the sparsity techniques in power system analysis.
3. Ability to develop computer program for various power flow studies.
4. Attain knowledge about the abnormal operation of power system under balanced and unbalanced conditions.
5. Understand the computational procedure for obtaining the swing curve.

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**COURSE OBJECTIVES:**
- To acquire fundamental knowledge in power system state estimation
- To gain knowledge in distribution system state estimation
- To perform observability analysis in the power system networks
- To obtain knowledge to assess the security of the electric power system
- To explore the strategies for power system operations enhancement
- To get conceptual aspects in power system state estimation and strategies to enhance the secure power system operations

**Introduction**


**Power System State Estimation**


**Network Observability Analysis**

**Distribution System State Estimation**

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.

**Security Assessment and Security Enhancement**

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- Contingency ranking and security indices-Correcting the generator dispatch for security enhancement using linearized DC models – Methods using sensitivity factors - Compensated factors - Optimization methods. Emergency and restorative control procedures.

**REFERENCES:**


**COURSE OUTCOMES:**

1. Understand the conceptual aspects in power system state estimation.
2. Demonstrate various state estimation methods.
3. Be proficient to perform observability analysis.
4. Able to conduct distribution state estimation.
5. Realize the security assessment and enhancement strategies.

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COURSE OBJECTIVES:

- To introduce the extra high voltage AC and DC transmission.
- To learn about the properties of bundle conductors and voltage control using compensators.
- To introduce the HVDC transmission system with types, control and protection.
- To discuss about the design factors of lines and cables.
- To learn about the overvoltage problem in extra high voltage system.

Introduction

Introduction to EHV AC and DC transmission - Role of EHV AC Transmission - Standard Transmission Voltages - Power-Handling Capacity and Line Loss - comparison between HVAC and HVDC overhead and underground transmission schemes - Factors concerning choice of HVAC and HVDC transmission - Block diagram of HVAC and HVDC transmission schemes.

EHV AC Transmission

Properties of bundled conductors - Surface voltage gradient on single and multi-conductor bundles - Corona effects - Power loss - Charge voltage diagram with Corona - Noise generation and their characteristics - Corona pulses, their generation and properties (qualitative study only)- Problems of EHV AC transmission at power frequency - Voltage control using compensators - Cascade connection of components.

HVDC Transmission

Analysis of DC transmission systems - Harmonics on AC and DC sides and filters for their suppression - Multi terminal D.C. Transmission systems; application, types, control and protection - Parallel operation of A.C. and D.C. transmission - Voltage stability in AC/DC systems - Modern developments in HVDC transmission - HVDC systems simulation.

EHV lines and Cable Transmission

Electrical Characteristics of EHV Cables - Properties of Cable-Insulation Materials - Breakdown and Withstand Electrical Stresses in Solid Insulation—Statistical Procedure -
Design Basis of Cable Insulation - Tests on Cable Characteristics - Surge Performance of Cable Systems - Gas Insulated EHV Lines - Design factors under steady state - Design basis of cable insulation.

Testing, Overvoltage and Design of EHV Systems


REFERENCES:


COURSE OUTCOMES:

1. Understand the basic comparison of HVAC and HVDC for overhead and underground transmission system.
2. Derive the surface voltage gradient of single, double, and more than three conductor bundles and expression for a charge voltage diagram for evaluation of the power loss.
3. Analyze the DC transmission system in case of harmonics and discuss about the multi terminal DC transmission system.
4. Gain Knowledge about the design factors about lines and cables.
5. Learn about protection of HVAC and HVDC systems.

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COURSE OBJECTIVES:

- To introduce the students to the field of programming and usage of software packages related to power systems such as MiPOWER, ETAP, PSCAD, C++, etc.
- To enhance the analyzing and problem solving skills of students.
- To deal with the practical aspects of the Core and Elective subjects offered in the Programme.
- To impart the practical insight of these subjects to the students through the actual implementation, analysis and/or simulation.

List of Experiments:
1. Formation of $Y_{bus}$ matrix by the method of inspection
2. Formation of $Y_{bus}$ using $Z_{bus}$ method
3. Load flow analysis using Gauss-Seidal method
4. Load flow analysis using Newton-Raphson method
5. Load flow analysis using Fast Decoupled Load flow method
6. State Estimation by Weighted Least Squares method
7. DC Load Flow method
8. Contingency Analysis
9. Double Line to Ground Fault Analysis
10. Symmetrical Short Circuit Analysis

COURSE OUTCOMES:

1. Know concepts in problem solving
2. Develop programming in C++ language
3. Analyze simulation results and effective documentation
4. Exhibit professional behavior and competence
5. Acquire expertise in usage of modern software tools

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COURSE OBJECTIVES:
- To bring out the need for operating the power system in a viable and affordable manner
- To get an overview of power system operation and control
- To emphasize on the development of algorithms suitable for efficient operation
- To point out the significance of unit commitment and hydro-thermal schedule
- To address the problems associated with interconnected networks, the need for maintaining co-coordinated actions and the use of controllers for smooth and satisfactory operation of power systems

Economic Operation of Power Systems


Optimal Power Flow


Hydrothermal Scheduling

Hydrothermal Coordination - hydroelectric plant models - Scheduling Problems - Short Term Hydro Thermal Scheduling - lambda-gamma method with losses - gradient approach - hydro units in series - pumped storage hydro scheduling - dynamic programming and linear programming base solution methods.

Unit Commitment


Automatic Generation Control

Basic generator control loops - speed governing system - isochronous governor - governors with speed-droop characteristics - speed regulation - load sharing by parallel generating units - control of power output of generating units - turbine model - generator load model - block diagram of an isolated power system - state space representation - fundamentals of automatic generation control - steady state analysis - concept of control area - AGC of two area interconnected power system - tie-line frequency bias control - bias for selection of bias factor - generation rate constraint - discrete integral controller for AGC.

REFERENCES:

COURSE OUTCOMES:
1. Gain knowledge on economic load dispatch.
2. Solve optimal power flow problems using various solution methods.
3. Get exposed to hydro thermal scheduling.
4. Understand the significance of Unit Commitment.
5. Focus on control aspects in power systems.

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COURSE OBJECTIVES:
- To explain the concept of power system protection.
- To detail the schemes for overcurrent protection.
- To describe the transformer protection schemes.
- To emphasize the protection of transmission lines.
- To acquire wide knowledge on Generator and Induction Motor Protection.
- To introduce the automation of substation.

Overcurrent Protection
Introduction

- need for protective systems
- nature and causes of faults
- types of faults
- effects of faults
- protection requirements
- protection zones
- primary and back-up protection
- directional protection
- classification of protective relays
- classification of protective schemes
- operating principles and relay construction

Overcurrent protection

- types of overcurrent relay
- overcurrent protective schemes
- protection of feeders and ring mains
- directional over-current relay
- drawbacks of over-current relays
- 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

**Transformer Protection**

- Types of faults in transformers
- over-current protection
- percentage differential protection of transformers
- percentage differential relay with harmonic restraint
- restricted earth fault protection
- protection against incipient faults
- protection against over-fluxing
- differential protection of bus bars
- protection against external and internal faults
- high impedance bus bar differential scheme
- supervisory relay
- protection of three-phase bus bars

**Protection of Transmission Lines**

- Distance protection
- simple impedance relay
- reactance relay
- mho relay
- comparison between distance relays
- distance protection of a three-phase line
- need for carrier-aided protection
- unit type carrier aided directional protection
- carrier-aided distance schemes for acceleration of zone II
- carrier-based phase comparison scheme

**Generator and Induction Motor Protection**

- Percentage differential protection scheme against stator phase and ground faults
- transverse differential protection
- protection against rotor faults
- protection against abnormal operating conditions
- unbalanced loading
- over speeding
- loss of excitation
- loss of prime mover
- induction motor protection
- protection against phase faults and ground faults
- protection against abnormal operating conditions from supply side and mechanical side

**Substation Automation**

- Topology and functionality
- system elements
- system requirements
- hardware implementation
- communication methods
- communication protocols and formats
- network protocols
- substation automation functionality
- system configuration and testing
- upgrading an existing substation
- communication networks for power systems automation
- introduction to IEC 61850
- advantages of IEC 61850

**REFERENCES:**

COURSE OUTCOMES:

1. Obtain fundamental knowledge about various protection schemes.
2. Become proficient in overcurrent and transformer protection schemes.
3. Gain familiarity about the protection of transmission lines.
4. Acquire knowledge on Generator and Induction Motor Protection.
5. Familiarize with the substation automation.

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COURSE OBJECTIVES:

- To introduce the concept of restructuring the power industry and market models
- To impart knowledge on fundamental concepts of congestion management
- To know about transmission pricing
- To understand the concepts of different ancillary services
- To illustrate various power sector in India

Introduction to Restructuring of Power Industry

Reasons for restructuring of power industry-Vertically Integrated Utilities and Power Pools-
Different Entities involved-Market models-Benefits from a Competitive Electricity Market-

Transmission Congestion Management

Transmission Open Access and Pricing


Ancillary Services Management

General Description of some Ancillary Services-Frequency control-Reserves services-Reactive power and voltage control service-Black start capability service- Scheduling and Dispatch Services- Synchronous Generators as Ancillary Service Providers – co-optimization of energy and reserve services.

Reforms in Indian Power Sector


REFERENCES:


COURSE OUTCOMES:

1. Understand the difference between traditional and restructured power systems
2. Acquire knowledge about various congestion management methods.
3. Familiarize with electricity pricing and transmission open access.
4. Get knowledge about significant ancillary services.
5. Learn about the reform initiatives undertaken in Indian power sector.

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**COURSE OBJECTIVES:**

- To distinguish between the different types of power system stability studies
- To impart knowledge on modeling of a synchronous machine for stability analysis
- To understand the concept of small signal stability
- To study the various solution methodologies for transient stability analysis
- To analyse the voltage stability assessment methods

**Introduction to Power System Stability**

Basic concepts and definitions - classification of stability - Rotor angle stability, voltage stability and voltage collapse - Distinction between mid-term and long-term stability - Nature of system response during severe upsets-blackouts around the world – ill effects of instability.

**Synchronous Machine Representation in Stability Studies**

Need for reduced order models – stability of interconnected systems - Simplifications essential for large scale studies – Simplified model with amortisseurs neglected – Constant flux linkage model – Reactive capability limits.

**Small Signal Stability**


**Transient Stability Analysis**


**Voltage Stability Analysis**

Difficulties with reactive power transmission – Steady state stability analysis of two bus system using PV and QV curves – Voltage stability assessment using indices – Determination
of weakest bus or weakest bus ordering vector – Large disturbance analysis – Phase balancing and power factor correction of unsymmetrical loads.

REFERENCES:

COURSE OUTCOMES:
1. Familiarize with the different types of stability in power systems.
2. Understand the modeling of synchronous machine.
3. Understand the significance about small signal stability analysis and its enhancement.
4. Investigate the various methods to enhance transient stability.
5. Know the significance of voltage stability analysis.

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COURSE OBJECTIVES:
- To introduce the students to the field of programming and usage of software packages related to power systems such as MiPOWER, ETAP, PSCAD, C++, etc.
- To enhance the analyzing and problem solving skills of students.
- To deal with the practical aspects of the Core and Elective subjects offered in the Programme.
• To impart the practical insight of these subjects to the students through the actual implementation, analysis and/or simulation

LIST OF EXPERIMENTS:

1. Optimal Power Flow Analysis
2. Economic Load Dispatch Analysis
3. Transient Stability Analysis
4. Dynamic Stability Analysis
5. Load Frequency Control of an isolated power system
6. Load Frequency Control of an interconnected two-area power system
7. Voltage Instability Analysis
8. Load Forecasting Analysis
9. Optimal Placement of Capacitor
10. Performance Analysis of Buck and Boost Converter

COURSE OUTCOMES:

1. Know concepts in problem solving
2. Develop programming in C++ language
3. Analyze simulation results and effective documentation
4. Exhibit professional behavior and competence
5. Acquire expertise in usage of modern software tools

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COURSE OBJECTIVES:

• To work on a technical topic related to Power Systems and acquire the ability of written and oral presentation
• To acquire the ability of writing technical papers for Conferences and Journals
The students will work for two periods per week guided by student counsellor. They will be asked to present a seminar of not less than fifteen minutes and not more than thirty minutes on any technical topic of student’s choice related to Power Systems and to engage in discussion with audience. They will defend their presentation. A brief copy of their presentation also should be submitted. Evaluation will be done by the student counselor based on the technical presentation and the report and also on the interaction shown during the seminar.

COURSE OUTCOMES:

1. The students will be getting the training to face the audience and to interact with the audience with confidence.
2. To tackle any problem during group discussion in the corporate interviews.

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COURSE OBJECTIVES:

- To carry out thesis work Phase – I which is an integral part of the thesis consisting of problem statement, literature review, thesis overview and scheme of implementation.
- To attempt the solution to the problem by analytical/simulation/experimental methods and validate with proper justification.

METHOD OF EVALUATION:

The student undergoes literature survey and identifies the topic of thesis and finalizes in consultation with Guide/Supervisor and prepare a comprehensive thesis report after completing the work to the satisfaction of the supervisor.

The progress of the thesis is evaluated based on a minimum of three reviews. The review committee will be constituted by the Head of the Department.

A thesis report is required at the end of the semester.

The thesis work is evaluated based on oral presentation and the thesis report jointly by external and internal examiners constituted by the Head of the Department.

COURSE OUTCOMES:

1. Review quality of Literature survey and Novelty in the problem
2. Assess clarity of Problem definition and Feasibility of problem solution
3. Validate the relevance to the specialization
4. Acquire Knowledge on the clarity of objective and scope
5. Improve the quality of Written and Oral Presentation

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**COURSE OBJECTIVES:**

- To train the students in the field work related the Power Systems and to have a practical knowledge in carrying out Power Systems field related works.
- To train and develop skills in solving problems during execution of certain works related to Power Systems.

The students individually undergo a training program in reputed concerns in the field of Power Systems during the summer vacation (at the end of second semester for full – time / fourth semester for part – time) for a minimum stipulated period of four weeks. At the end of the training, the student has to submit a detailed report on the training he had, within ten days from the commencement of the third semester for Full-time / fifth semester for part-time. The students will be evaluated, by a team of staff members nominated by Head of the department, through a viva-voce examination.

**COURSE OUTCOMES:**

1. The students can face the challenges in the field with confidence.
2. The students will be benefited by the training with managing the situation that arises during the execution of works related to Power Systems.

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COURSE OBJECTIVES:

- To carry out Thesis work Phase – II which the remaining part of the thesis.
- To attempt the solution to the problem by analytical/simulation/experimental methods and validate with proper justification.

METHOD OF EVALUATION:

The progress of the thesis is evaluated based on a minimum of three reviews. The review committee will be constituted by the Head of the Department.

A thesis report is required at the end of the semester.

The thesis work is evaluated based on oral presentation and the thesis report jointly by external and internal examiners constituted by the Head of the Department.

COURSE OUTCOMES:

1. Identify the real world power system problems
2. Analyze, design and implement solution methodologies
3. Apply modern engineering tools for solution
4. Write technical reports following professional ethics
5. Develop effective communication skills to present and defend their research work to a panel of experts.

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COURSE OBJECTIVES:

- To provide knowledge on FACTS controllers
- To introduce the reactive power control techniques
- To convey the significance of FACTS as power electronic interface
- To describe how the FACTS controller can provide controllability of voltage, impedance, reactive power & active power flow and enhance stability
- To study the characteristics, modeling and operating schemes of different types of shunt and series switched reactive power generating devices
- To familiarize the reader about various techniques for co-ordination of the different FACTS controllers and algorithm for their effective operation, design and stability

**Introduction**


**Static VAr Compensators (SVC)**


**Static Series Compensators (SSC)**

Objectives of Series Compensation – Variable impedance type Series Compensators – Modeling and operating control schemes of GCSC, TSSC,TCSC – Sub Synchronous characteristics – Variable reactance model – Modeling for Stability studies – Switching Converter type Series Compensators – Model and 42 Operating Control scheme of SSSC – Capability to provide real power Compensation.

**Emerging FACTS Controllers**

Static Synchronous Compensator (STATCOM) – Transfer function model – Dynamic performance – Capability to exchange real power – Operation in unbalanced ac systems – Comparison between STATCOM and SVC – Special purpose FACTS Controller – NGHSSR Damping Scheme – Thyristor Controlled Braking resistor –Generalized and multifunctional FACTS Controllers.

**Co-ordination of FACTS Controllers**


**REFERENCES:**

COURSE OUTCOMES:

1. Exposed to new methods adopted in power system control.
2. Be trained with modeling and development of new devices needed for reactive power control.
3. Familiarize with quantitative treatment of all types of FACTS controllers.
4. Equip with basic procedure of FACTS controller Design.
5. Ability to develop controller design.

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COURSE OBJECTIVES:

- To familiarize with the fundamentals of smart grids
- To get exposed to Smart Grid technologies, functionalities and capabilities
- To study about the performance analysis tools for smart grid
- To know about the various stability assessment tools for smart grid
- To focus on smart metering and demand-side integration
- To familiarize with the application of FACTS and Energy storage devices in smart grid
Introduction
Motivation for smart grid- smart grid Definition -benefits- Comparison of Traditional Grid and Smart Grid-Characteristics of a Smart Grid -Stakeholders in smart grid development-Smart grid technology framework , functionalities and capabilities- Cost Components for the Smart Grid: Transmission Systems and Sub-Stations End- Distribution End- Consumer End-Cost-Benefit Analysis

Load Flow and Contingency Analysis for Smart Grid
Introduction to Load Flow Studies - Challenges to Load Flow in Smart Grid - Weaknesses of the Present Load Flow Methods - Load Flow methodology for Smart Grid Design - DSOPF Application To The Smart Grid- Static Security Assessment (SSA) and Contingencies - Contingencies and Their Classification - Contingency Studies for the Smart Grid.

Stability Assessment for Smart Grid

Smart Metering

FACTS and Energy Storage in the Smart Grid

REFERENCES:

COURSE OUTCOMES:
1. Acquire knowledge on the concept of smart grids.
2. Implement Load flow and contingency methods for smart grid.
3. Identify stability assessment tools for smart grid.
4. Gain knowledge on smart metering infrastructure.
5. Realize the application of FACTS and energy storage devices in smart grid.

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**COURSE OBJECTIVES:**

- To educate the students significantly the concept of wind energy system.
- To prepare students to excel in research in wind energy system.
- To impart knowledge in solar energy system through global, rigorous post graduate education.
- To make the students to understand the new developments in solar energy system.
- To provide students with a solid foundation in mathematical, scientific and engineering fundamentals required to solve wind and solar energy problems.
- To train students with good scientific and engineering knowledge so as to comprehend, analyze, design, and create novel products and solutions for the real time problems.

**Introduction**

Wind resources – Nature and occurrence of wind – Power in the wind – Wind characteristics – Principles of wind energy conversions – Components of wind energy conversion system (WECS) – Classification of WECS – Advantages and disadvantages of WECS.

**Wind Electric Generators**


**Wind Power Management**
Wind energy storage – Storage systems – Wind farms and grid connections – Grid related problems on absorption of wind – Grid interfacing arrangement – Simulation of wind energy conversion system – Operation, Control and technical issues of wind generated electrical energy – Inter connected operation – Hybrid systems.

**Introduction to Solar Energy and Its Prospects**

**Photo Voltaic System**
A basic photo voltaic system for power generation – Advantages and disadvantages of photo voltaic solar energy conversion – Application of solar photo voltaic system – Power conditioning and storage arrangement – Maximum power point tracking - Introduction to string inverters.

**REFERENCES:**

**COURSE OUTCOMES:**
1. Understand the basic concept of wind energy conversion system.
2. Impart knowledge on wind electric generators in power systems.
3. Develop skill to control the wind generated electrical energy.
4. Train to know about the various types of solar collectors and its storage.
5. Make to understand the basic knowledge of photo voltaic system.

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COURSE OBJECTIVES:

- To familiarize about forms of Energy
- To learn the present energy scenario and the need for energy management
- To understand energy management concepts and various methods
- To understand the basic components of energy audit
- To learn the various techniques of energy audit and usage of instruments
- To analyse and report the outcome of energy audit

Introduction

Energy Management

Energy Audit
Definition, Energy audit- need, Types of energy audit - Preliminary audit, detailed audit, methodology and approach - Instruments for energy audit - Energy saving calculations.

Energy Assessment and Reporting

Energy Economics

REFERENCES:


COURSE OUTCOMES:

1. Understand and to acquire fundamental knowledge in the field of energy and on both the conventional and non-conventional energy technologies.
2. Acquire the capability and skills needed for the energy monitoring, auditing and management of Energy.
4. Understand the need for energy audit, types and Instruments for energy audit.
5. Capable for Report writing and presentation of energy audit.

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PSEEX0X DISTRIBUTED GENERATION AND MICROGRIDS

COURSE OBJECTIVES:

- To familiarize with the concept of Distributed Generation
- To expose the various distributed energy resources
- To focus on the planning and protection of Distributed Generation
- To study the concept of Microgrid
- To analyze the impact of Microgrid
- To understand the major issues on Microgrid economics

Introduction to Distributed Generation

DG definition-Reasons for distributed generation-Benefits of integration-Distributed generation and the distribution system-Technical, Environmental and Economic impacts of distributed generation on the distribution system-Impact of distributed generation on the transmission system-Impact of distributed generation on central generation
Distributed Energy Resources
Combined heat and power (CHP) systems-Wind energy conversion systems (WECS)- Solar photovoltaic (PV) systems-Small-scale hydroelectric power generation-Other renewable energy sources-Storage devices-Inverter interfaces

DG Planning and Protection
Generation capacity adequacy in conventional thermal generation systems-Impact of distributed generation-Impact of distributed generation on network design-Protection of distributed generation-Protection of the generation equipment from internal Faults-Protection of the faulted distribution network from fault currents supplied by the distributed generator-Impact of distributed generation on existing distribution system protection.

Concept of Microgrid
Microgrid Definition-A typical Microgrid configuration- Functions of Micro source controller and central controller- Energy Management Module (EMM) and Protection Coordination Module (PCM)- Modes of Operation- Grid connected and islanded modes-Modelling of Microgrid- Microturbine Model- PV Solar Cell Model- Wind Turbine Model-Role of Microgrid in power market competition.

Impacts of Microgrid

REFERENCES:

COURSE OUTCOMES:
1. Understand the concepts of Distributed Generation and Micro grids.
2. Gain Knowledge about the various DG resources.
3. Familiarize with the planning and protection schemes of Distributed Generation.
4. Learn the concept of Microgrid and its mode of operation.
5. Acquire knowledge on the impacts of Microgrid.

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COURSE OBJECTIVES:

- To develop students with an understanding of the characteristics of modern electric drive systems for different applications
- To brief the various control techniques involved with both DC and AC Drives
- To gain knowledge about operation of D.C motor speed control using converters and choppers
- To enable the students identify the need and choice for various drives
- To acquire the knowledge of different speed control methods in A.C motors
- To brief about the working principle of Special Electrical Drives

DC Drives
Introduction-fundamentals of electric drives- comparison between conventional and solid state drives-open loop and closed loop speed control- motor transfer function-speed and current loops-load torque disturbance
Separately excited D.C motor and series motor drive-waveforms – equations-performance characteristics -operation of semi and full converters- reversible drives using dual converters-armature and field current reversal

Chopper Controlled Drives (Using Devices Other Than Thyristors)
Chopper fed D.C motors, analysis and performance characteristics-Dynamic and regenerative braking of chopper controlled drives-regenerative reversals-transit systems.

Induction Motor Drives
Stator voltage control of induction motor-adjustable voltage. Constant voltage/frequency operation, torque characteristics-stator current control-controlled slip operation-Rotor resistance control-types of rotor choppers-typical rotor chopper circuits-slip power recovery scheme-static Kramer and Scherbius drives systems

**Synchronous Motor Drives**

Adjustable frequency operation-controlled current operation-voltage source and current source inverter fed synchronous motor drive-PWM inverter fed synchronous motor drive-cycloconverter fed synchronous motor drive-torque angle control of the self-controlled synchronous motor drive

**Special Machines Drives**

Principle of operation-torque speed characteristics of Switched Reluctance Motor (SRM) drives and Brushless DC motor (BLDC)-Permanent magnet synchronous motors-Principle of operation, UPF operation, torque speed characteristics

**REFERENCES:**


**COURSE OUTCOMES:**

1. Model and analyze electrical motor drives and their sub systems (converters, rotating machines and loads)
2. Choose a suitable power electronic converter structure for an electrical motor drive
3. Choose a suitable control structure and calculate control parameters for an electrical motor drive
4. Select suitable Special Electrical Drive and apply appropriate control method for the application.
5. Able to use the techniques, skills and modern engineering tools necessary for engineering practice

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COURSE OBJECTIVES:

- To review the mathematical background of various power system components that enables the operator to construct efficient system model during various operating states is expected.
- To introduce the basics of dynamics and stability problems based on the modelling of synchronous machines.
- To bring out the importance of various modelling of excitation and speed governing systems in detail.
- To facilitate extension of the existing techniques in understanding the fundamental concepts of active power flow control to ensure stability of dynamic systems.
- To make the students realize the significance of various methodologies and to study various remedial measures in ensuring a better reactive power flow control.
- To study various power system stabilizers in enhancing better dynamic control of the power system.

Introduction

Concept and importance of power system stability in the operation and design – distinction between transient and dynamic stability – complexity of stability problem in large system – necessity for reduced models – stability of interconnected systems.

Machine Modelling and Machine Controllers


Modelling of Classical Power Plant Components


Active Power Flow Control
Small and large disturbances and deviations - UCTE load frequency control – primary, secondary and tertiary control - system modeling, inertia, droop, regulation, and dynamic frequency response - block diagram of the system dynamics and load damping - effect of governor droop on regulation - increasing load by adjusting prime mover power - spinning reserves - Under Frequency Load Shedding and operation in islanding.

**Reactive Power Flow Control**


**REFERENCES:**


**COURSE OUTCOMES:**

1. Understand about various approaches in modelling of power system components and analyze for the dynamic operation of the power system
2. Handle modern speed governing and turbine systems for various classical power plants
3. Obtain improved skills with the detailed study of various IEEE type excitation systems for improved power system operation, stability, control and protection.
4. Ensure enhanced capability in adopting efficient engineering aspects for real power - frequency and reactive power – voltage controls of electrical energy generation and utilization.
5. Have clear understanding of managerial functions like planning, organizing, controlling various power system utilities.

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**COURSE OBJECTIVES:**

- To impart knowledge on the travelling wave phenomena
- To study about the switching transients
- To learn about the lightning-induced transients
- To acquire knowledge on the modeling of various power apparatus
- To familiarize with the concept of Insulation Coordination

**Travelling Waves**

Velocity of Travelling Waves and Characteristic Impedance- Energy Contents of Travelling Waves- Attenuation and Distortion of Electromagnetic Waves- The Telegraph Equations-The Lossless Line- The Distortion less Line- Reflection and Refraction of Travelling Waves- Reflection of Travelling Waves against Transformer- and Generator-Windings- The Origin of Transient Recovery Voltages- The Lattice Diagram

**Switching Transients**

Interrupting Capacitive Currents- Capacitive Inrush Currents- Interrupting Small Inductive Currents- Transformer Inrush Currents- The Short-Line Fault- Characteristics of the Transient Recovery Voltage- The Transient Recovery Voltage for Different Types of Faults

**Lightning-induced Transients**

Modeling of Power Apparatus


Insulation Coordination

Basic ideas about Insulation Coordination- The strength of insulation- The Hierarchy of Insulation Coordination – Test Voltage waveforms and Transient ratings – Deterministic and Statistical Approaches to Insulation Coordination

REFERENCES:


COURSE OUTCOMES:

1. Understand the travelling wave phenomena
2. Analyze the switching transients
3. Study about the lightning-induced transients
4. Learn about the modeling of various power apparatus
5. Get exposed to the topic of Insulation Coordination

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PSEEX0X | POWER SYSTEM RELIABILITY | L | T | P
COURSE OBJECTIVES:

1. To introduce the basic concepts of reliability engineering
2. To understand hierarchical levels in power system reliability assessment
3. To study the formation of system model
4. To learn the importance of reliability indices in power system planning, expansion, operation and control

Introduction


Generating Capacity: Basic Probability Methods


Generating Capacity: Frequency and Duration Method


Composite Generation and Transmission System


Distribution System


REFERENCES:


COURSE OUTCOMES:

1. Acquire design knowledge of system components in reliability point of view.
2. Understand the importance of customer oriented and system oriented indices.
3. Familiarize with reliability evaluation methodologies.
4. Analyse the system performance with proper remedial strategies.
5. Enrich the capability of analysing reliability design alternatives in engineering systems

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COURSE OBJECTIVES:

- To introduce the definition of power quality disturbances along with cause, detrimental effects and mitigation methods.
- To introduce the harmonic sources and harmonic filters.
- To introduce the power quality standards
- To understand the concepts of power quality improvement methods.
- To familiarize the students how the capacitor allocation problem formulation changes in the presence of harmonics from normal sinusoidal operating conditions.
Introduction to Power Quality


Analysis and Conventional Mitigation Methods

Analysis of Power Outages - Analysis of Unbalance – Analysis of Distortion: Online extraction of fundamental sequence components from measured samples – Analysis of Voltage Sag: Voltage Sag Lost Energy Index (VSLEI) – Analysis of Flicker.


Harmonic Filters


Power Quality Improvement


Optimal Placement and Sizing of Shunt Capacitor Banks in the Presence of Harmonics


Reformulation of the Capacitor allocation Problem to account for Harmonics – System model at fundamental and harmonic frequencies – Constraints – Objective function (Cost index).

REFERENCES:


COURSE OUTCOMES:

1. Understand the various power quality phenomenon and their Standards.
2. Understand different types of power quality problems with their source of generation.
3. Design different methodologies for detection, classification and mitigation of power quality problems. Expected to practically design active & passive filters for harmonic elimination.
4. Understand how the improvement in power quality is achieved via custom power devices.
5. Familiar with formulation of the capacitor placement problem in the presence of harmonics.

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COURSE OBJECTIVES:

- To impart knowledge on basic design concept.
- To solve linear and non-linear state equations.
- To understand about the role of controllability and Observability.
- To educate on stability analysis.
- To learn about modal concepts.
- To get familiarised with design of state and output feedback controllers.
Basics of Design Concepts

Design specifications-sensitivity and stability- Limitations- Controller structure- one and two
degrees of freedom- PID controllers and Lag-lead compensators- Root locus design, Design
using bode plots and Routh- Hurwitz criterion - Design examples.

State Variable Representation

Concept of State-State equation for Dynamic Systems -Time invariance and linearity- Non
uniqueness of state model-State Diagrams, Existence and uniqueness of solutions to
Continuous-time state equations-Solution of Nonlinear and Linear Time Varying State
equations-Role of Eigenvalues and Eigenvectors.

Controllability and Observability

Effect of sampling on controllability, Observability, State and output feedback observers,
estimated state feedback-Stabilizability and Detectability-Test for Continuous time Systems-
time varying and Time invariant case- Reducibility-System Realizations.

Stability Analysis

Introduction-Equilibrium Points-Stability in the sense of Lyapunov-BIBO Stability-Stability of
LTI Systems-Equilibrium Stability of Nonlinear Continuous Time Autonomous Systems-
The Direct Method of Lyapunov and the Linear/ Non-linear Continuous-Time Autonomous
Systems.

Modal Control

Introduction-Controllable and Observable Companion Forms-SISO and MIMO Systems-The
Effect of State Feedback on Controllability and Observability-Pole Placement by State
Feedback for both SISO and MIMO Systems-Full Order and Reduced Order Observers.

REFERENCES:

   Indian reprint 2009.
4. Graham C. Goodwin, Stefan F. Graebe and Mario E. Salgado, “Control system

COURSE OUTCOMES:

1. Learn the basic design concepts with examples.
2. Gain an enhanced knowledge about state space analysis.
3. Attain knowledge about time varying and time invariant feedback concepts.
4. Acquire conceptual knowledge about stability analysis.
5. Familiarize about modal control concepts.
COURSE OBJECTIVES:

- To detail the function of electric power distribution network.
- To derive the voltage profile enhancement and protection schemes.
- To evaluate the reliability of the electrical distribution system.
- To detail the automation schemes in various sections like substation, feeder, etc.,
- To derive the strategies for distribution system expansion.
- To acquire wide knowledge in distribution system operation, protection, control and expansion planning of distribution system architecture

Distribution Systems

Distribution systems: Types of distribution systems - Section and size of feeders – Primary and secondary distribution – Distribution substations – Effect of working voltage on the size of feeders and distributors – Effect of system voltage on economy – Voltage drop and efficiency of transmission - Qualitative treatment of rural distribution and industrial distribution.

Control and Protection

Voltage control: Application of shunt capacitance for loss reduction – Harmonics in the system – Static VAR systems – Voltage profile enhancement schemes.

System protection: Fuses and section analyzers - Over current protection - Under voltage and under frequency protection – Coordination of protective device.

Reliability Analysis

Primary and secondary system design considerations - Primary circuit configurations - Primary feeder loading - Secondary networks design- Economic design -Unbalance loads and voltage considerations.
Distribution Automation


Expansion Planning


REFERENCES:


COURSE OUTCOMES:

1. Obtain fundamental knowledge in electric power distribution system.
2. Be proficient in control and protection schemes for distribution systems.
3. Gain familiarity to evaluate reliability of distribution systems.
4. Demonstrate the methodologies for distribution automation.
5. Able to develop strategies for expanding the existing distribution systems

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COURSE OBJECTIVES:

1. To give an insight to the students about the significance of soft computing techniques and artificial neural networks.
2. To teach the importance, architecture, algorithm and application of artificial neural networks.
3. To impart knowledge on fuzzy logic systems.
4. To give exposure to genetic algorithm and swarm optimization methods.

Introduction and Artificial Neural Networks

Introduction of soft computing – Comparison of soft computing and hard computing – types and applications of soft computing techniques - Biological neural networks – Evolution of Neural Networks – Basic Models of Artificial Neural Networks – Terminologies of ANNs – Learning and Training the neural network – McCulloch-Pitts neuron model – Perceptron Model – Back propagation network.

Associative Memory and Unsupervised Neural Networks


Fuzzy Logic System


Genetic Algorithm


Swarm Optimization
Basic concept of Swarm intelligence - Ant colony optimization (ACO) - Particle swarm optimization (PSO) and Artificial Bee colony algorithm (ABC). Application of above algorithms in power system optimization problems.

REFERENCES:

COURSE OUTCOMES:
1. Understand the concept, architecture and algorithm
2. Familiarize with the application of various artificial neural networks.
3. Acquire knowledge about fuzzy logic systems.
4. Implement genetic algorithm for various power system optimization problems.
5. Get introduced to various swarm optimization methods.

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COURSE OBJECTIVES:
- To introduce the fundamental concepts of optimization techniques.
- To acquire sound knowledge of obtaining optimal solutions to the power system problems with the help of different mathematical techniques.
- To understand various algorithms with their comparative study for the utilization of optimization problem solution.
- To analyse the concepts of various classical and modern methods for constrained and unconstrained problems.
- To gain in-depth knowledge about variety of performance measures for optimization problems applied in the engineering fields.

Introduction to Optimization


Linear Programming

**Non Linear Programming**


**Geometric Programming and Integer Programming**

Geometric programming - Polynomial – Unconstrained minimization problem – Constrained minimization problem Primal and Dual programs – Geometric programming with mixed inequality constraints – Complementary geometric programming.
Integer linear programming – Mixed integer programming – Integer non linear programming – Sequential linear discrete programming.

**Dynamic Programming**

Multistage decision processes – Concept of sub optimization – Principle of optimality – Computational procedure in dynamic programming - Conversion of a final value problem into an initial value problem – Linear programming as a case of dynamic programming – Continuous dynamic programming.

**REFERENCES:**


**COURSE OUTCOMES:**

1. Apply concepts of mathematics to formulate an optimization problem.
2. Understand and apply the concept of optimality criteria for various types of optimization problems.
3. Solve various constrained and unconstrained problems in single variable and multivariable domains.
4. Apply the methods of optimization in practical conditions.
5. Analyze a research problem having requirement of optimization techniques.

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**COURSE OBJECTIVES:**
- To know the principles of cloud computing
- To study the various cloud service models
- To understand the basics of virtualization
- To familiarize with the programming models available in cloud
- To get an insight on some applications and prospects of cloud computing

**An Overview**


**Cloud Services**

Cloud services-classification- software as a service (SaaS), platform as a service (PaaS), and infrastructure as a service (IaaS)- data storage as a service- other services- security as a service (SeaaS), knowledge as a service, and analytics as a service (AaaS)-service providers-Cloud Deployment Models- Private Cloud-Public Cloud-Community Cloud-Hybrid Cloud

**Virtualization**

Introduction- Virtualization Opportunities- Processor Virtualization- Memory Virtualization Storage Virtualization - Network Virtualization - Data Virtualization Application Virtualization -Approaches to Virtualization- Full Virtualization – Para virtualization - Hardware-Assisted Virtualization -Types of Hypervisors- From Virtualization to Cloud Computing- IaaS- PaaS- SaaS

**Programming Models for Cloud Computing**


**Applications and Prospects**

REFERENCES:


COURSE OUTCOMES:

1. Conceptualize the basic ideas and motivation for cloud computing
2. Familiarize with the cloud services offered by the companies
3. Understand the concept of Virtualization.
4. Discuss the suitability of each programming model to different kinds of application.
5. Identify the areas of application and explore future prospects.

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COURSE OBJECTIVES:

- To gain a sound knowledge of scientific research for undertaking a valid study
- To explore the techniques of defining a research problem and investigate the various research designs, highlighting their main characteristics
- To familiarize with the art of Technical Communication
- To study the different types of Listening and Speech Techniques
- To realize the art of writing technical reports and proposals
- To understand the ethical issues of writing technical papers

Scientific Research

Research-Definition-Objectives and Motivation - Characteristics of scientific research activity - Means and methods of scientific research - Criteria of Good Research-Limitations-Components of a research problem-selecting the problem-necessity of defining the problem-technique involved in defining a problem—Importance of literature review in defining a problem—Identifying gap areas from literature review-Research design-need for research design-features of a good design-important concepts relating to research design-different research designs
Technical Communication

Importance of Technical Communication-Salient features of Technical Communication - Technical communication Vs. General communication-Objectives and characteristics of Technical Communication-Levels of communication-Flow of communication-Visual Aids in Technical Communication-Types of Barriers to communication

Listening and Speech Techniques

Types of listening, listening with a purpose, barriers to listening, listening comprehension, effective listening strategies, listening in conversational interaction, team listening-Speech techniques-Conversation and oral skills, strategies for good conversation, techniques to develop effective word accent, word stress, primary and secondary stress, use of correct stress pattern, developing voice quality, developing correct tone.

Technical Reports and Proposals

Technical Reports- Importance of Reports- Objectives of Reports- characteristics of a report-categories of reports- formats- structure of reports- writing the report- first draft- revising, editing, and proofreading-Technical proposals- definition and purpose- types- sales proposals and research proposals- characteristics- structure of proposals- preparation, budgeting, presentation, funding agencies for engineering research- evaluation of proposals

Technical Papers and Descriptions


REFERENCES:


COURSE OUTCOMES:

1. Understand the concept of Research Methodology and develop a preliminary research design for projects in the field of expertise
2. Know the significance of Technical communication
3. Familiarize with the different types of Listening and Speech Techniques
4. Prepare technical reports and proposals as per guidelines
5. Implement the acquired knowledge in preparation of technical papers.
COURSE OBJECTIVES:

- To understand the concepts of Internet of Things
- To conceptualize Cloud computing and Fog computing
- To familiarize with the IOT Services and protocols
- To gain knowledge on the Security and privacy in IoT
- To explore the application areas where IoT can be applied

Introduction

Definition-benefits-IoT architectures- a reference architecture-service-oriented architecture-API-oriented architecture-taxonomy of resource management activities in IoT-various protocols in IoT communication layers-IoT applications-challenges and research domains

IoT Services

Open IoT architecture and functionalities-scheduling process and IoT services lifecycle-workflow associated with the service registration process-update resources service-process of unregistering a service-scheduling and resource management

IoT Protocols


Programming Frameworks, Cloud and Fog Computing

Minimal features to be fulfilled-IoT programming approaches-existing IoT frameworks-highlights of various IoT programming frameworks-Cloud Computing and Fog computing-Principle of Cloud computing- Architecture-cloud computing Vs fog computing-definitions and characteristics of Fog Computing-reference architecture for fog computing-applications

Security and Privacy in IoT

IoT reference model-IoT security threats-IoT security requirements-taxonomy of security attacks, threats, and security mechanisms-network and transport layer challenges-IoT gateways and security-IoT routing attacks-bootstrapping and authentication-authorization mechanisms-security frameworks for IoT-privacy in IoT networks

REFERENCES:

COURSE OUTCOMES:

1. Acquire knowledge on IoT
2. Familiarize with IoT services
3. Analyze various protocols for IoT
4. Distinguish between cloud and Fog computing
5. Learn about the Security and privacy in IoT

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COURSE OBJECTIVES:

1. To provide an insight into the laws related to intellectual property
2. To familiarize with the steps required for protecting, managing and enforcing intellectual property rights
3. To study each field within the umbrella of intellectual property, namely, trademarks, copyrights, patents, trade secrets and unfair competition.
4. To address new and international developments for each of the fields of intellectual property.
5. To encourage students at all levels to develop patentable technologies

Introduction to Intellectual property rights

Definition- Intellectual property vs. physical property-importance of Intellectual property - Types - International Organizations, Agencies and Treaties - History of Intellectual property rights(IPR) in India, Overview of IP laws in India, Indian IPR, Administrative Machinery, Major international treaties signed by India

Copyright

Meaning of copyright- Classes of works for which copyright protection is available- The Rights afforded by Copyright Law - Copyright Ownership, Transfers, and Duration- Copyright Registration- Copyright Infringement- powers of Copyright Board- The Copyright (Amendment) Bill, 2012- The Information Technology Act, 2000.-Internet and Copyright
issues—Authorship under Copyright—Plagiarism—Detection and Consequences—Plagiarism policy and regulations

**Patents and Designs**

**Trademark**

**Intellectual Property Management**

**REFERENCES:**

**COURSE OUTCOMES:**
1. Understand the concept of Intellectual property rights.
2. Familiarize with the copyright laws.
3. Acquire knowledge on Patenting and Design.
4. Learn about Trademark and Trade secrets law.