ANNAMALAI UNIVERSITY
FACULTY OF ENGINEERING AND TECHNOLOGY
M.E. (Two -Year Full Time) DEGREE PROGRAMME (CBCS)
IN
POWER SYSTEMS ENGINEERING
REGULATIONS – 2023

1. **Conditions for Admission**

   Candidates for admission to the first year of the four-semester **M.E 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. Theyshall satisfy the conditions regarding qualifying marks and physical fitness as may be prescribed by the Syndicate of the Annamalai Universityfromtimetotime.

2. **Branches of Study in M.E**

   The Branch and Eligibility criteria of Programmes are given in Annexure

3. **Courses of Study**

   The courses of study along with the respective syllabi and the scheme of Examinations for each of the M.E Programmes offered by the different Departments of study in the Faculty of Engineering and Technology are given in Annexures of the respective Departments.

4. **Choice Based Credit System (CBCS)**

   The curriculum includes Program Core, Program Electives and Open Electives, Mandatory Learning Courses and Audit Courses in addition to the Thesis. Each semester curriculum shall normallyhave a blend of theoryand practical courses.

5. **Assignment of Credits for Courses**

   Each course is normally assigned one credit per hour of lecture / tutorial per week and 0.5 credit for one hour of laboratory or project or industrial training or seminar per week. The total credits for the Programme will be **68**.

6. **Duration of the Programme**

   A student of M.E Programme is normally expected to complete in four semesters for the full-time but in any case not more than four years from the date of admission.

7. **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 Phase-II shall be done at the appropriate semesters.

8. Electives

Program Electives

The student has to select two electives in first semester, another two electives in the second semester and one more in thethird semesterfrom the list of Program Electives.

Open Electives

The student has to select two electives in third semester from the list of Open Electives offered by the Department and / or other departments in the Faculty of Engineering and Technology.

9. Industrial Project

A student may be allowed to take up the one program elective and two open elective courses of third semester (Full Time program) in the first and second semester, to enable him/her to carry out Project Phase-I and Phase-II in an industry during the entire second year of study. The condition is that the student must 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.

10. Assessment

Theory Courses

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

First assessment (Mid-Semester Test-I)	:	08 marks
Second assessment (Mid-Semester Test-II)	:	12 marks
Third Assessment	:	05 marks
End Semester Examination	:	75 marks

Practical Courses

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

Firstassessment(Test-I)	:	15 marks
Secondassessment(Test-II)	:	15 marks
Maintenanceofrecordbook	:	10 marks
End Semester Examination	:	60 marks

Thesis Work

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.

Seminar / Industrial Training

The continuous assessment marks for the seminar / industrial training will be 40 and to be assessed by a seminar committee consisting of the Seminar Coordinator and a minimum of two members nominated by the Head of the Department. The continuous assessment marks will be awarded at the end of the seminar session. 60 marks are allotted for the seminar / industrial training and viva voce examination conducted based on the seminar / industrial training report at the end of the semester.

11. Student Counselors (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 counselor (mentor) for those students throughout their period of study.

12. Class Committee

For each of the semesters of M.E 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 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 Thesissupervisors.
- 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 Departmentmay 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 bedecided.

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 courses / 40 marks for practical courses, for Industrial Training and for Thesis work (Phase-I and Phase-II) 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.**

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 foreach 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.

90 to 100 marks	Grade S‘
80 to 89 marks	Grade A‘
70 to 79 marks	Grade B‘

60 to 69 marks	Grade C‘
55 to 59 marks	Grade D‘
50 to 54 marks	Grade E‘
Less than 50 marks	Grade RA‘
Withdrawn from the Examination	Grade W ‘

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 68 credits within four semesters 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 68 credits within two years and six months from the time of admission and obtain a CGPA of 6.75 or above.

For Second class, the student must earn a minimum of 68 credits within four years from the time of admission.

The conversion of OGPA/CGPA (from I semester to IV Semester) to the corresponding Percentage of marks may be calculated as per the following formula:

Percentage of marks = (OGPA/CGPA - 0.25) x 10

Where $OGPA/CGPA = \frac{\sum C_i GP_i}{\sum C_i}$

C_i- Credit hours of a course

GP_i - Grade Point of that course

18. Ranking of Candidates

The candidates who are eligible to get the M.E degree in First Class with Distinction will be rankedonthebasis of CGPAforallthecourses ofstudy fromI toIV semester.

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.

19. Transitory Regulations

If a candidate studying under the old regulations M.E 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

S. No.	Department		Programme (Full Time)	Eligible B.E. / B.Tech Programme
1	Civil Engineering	i	Environmental Engineering	B.E. / B.Tech - Civil Engineering, Civil &Structural Engineering, Environmental Engineering, Mechanical Engineering, Industrial Engineering, Chemical Engineering, Bio Chemical Engineering, Biotechnology, Industrial Biotechnology, Chemical & Environmental Engineering.
		ii	Water resources Engineering & Management	B.E. / B.Tech - Civil Engineering, Civil &Structural Engineering, Environmental Engineering, Mechanical Engineering, Agricutural and irrigation Engineering, Geo informatics, Energy and Environmental Engineering.
2	Civil & Structural Engineering	i	Structural Engineering	B.E. / B.Tech - Civil Engineering, Civil & Structural Engineering.
		ii	Construction Engineering. and Management	
3	Mechanical Engineering	i	Thermal Power	B.E. / B.Tech - Mechanical Engineering, Automobile Engineering, Mechanical Engineering (Manufacturing).
		ii.	Energy Engineering & Management	B.E. / B.Tech - Mechanical Engineering, Automobile Engineering, Mechanical (Manufacturing) Engineering, Chemical Engineering
4	Manufacturing Engineering	i	Manufacturing Engineering	B.E. / B.Tech - Mechanical Engineering, Automobile Engineering, Manufacturing Engineering, Production Engineering, Marine Materials science Engineering,Metallurgy Engineering, Mechatronics Engineering and Industrial Engineering.
5	Electrical Engineering	i	Power System Engineering	B.E. / B.Tech - Electrical and Electronics Engineering,
6	Electronics & Instrumentation Engineering	i	Process Control & Instrumentation	B.E. / B.Tech - Electronics and Instrumentation Engineering, Electrical and Electronics Engineering, Control and Instrumentation Engineering, Instrumentation Engineering, , Electronics and Communication Engineering,
7	Chemical Engineering	i	Chemical Engineering	B.E. / B.Tech - Chemical Engineering, Petroleum Engineering, Petrochemical Technology
		ii	Food Processing Technology	B.E. / B.Tech - Chemical Engineering, Food Technology,Biotechnology, Biochemical Engineering, Agricultural Engineering.

S. No.	Department		Programme (Full Time)	Eligible B.E. / B.Tech Programme
8	Computer Science and Engineering	i	Computer Science and Engineering	B.E. / B.Tech - Computer Science and Engineering, Computer Science and Engineering (Artificial Intelligence and Machine Learning), Computer Science and Engineering (Data Science), Information Technology, Electronics & Communication Engineering, Software Engineering
9	Electronic & Communication Engineering	i.	Communication Systems	B.E. / B.Tech -Electronics and Communication Engineering, Electronics Engineering.

DETAILS OF COURSE CODE

S. No	3rd & 4th Digits	DETAILS		5th & 6th Digits	DETAILS	7th & 8th Digits	DETAILS
1	CE	Civil Engineering	I	WR	Water Resources Engineering & Management	PC	Program Core
			II	EE	Environmental Engineering		
2	CZ	Civil & Structural Engineering	I	SE	Structural Engineering	PE	Program Elective
			II	CM	Construction Engineering. and Management		
3	ME	Mechanical Engineering	I	TP	Thermal Power Engineering	OE	Open Elective
			II	EM	Energy Engineering & Management		
4	MF	Manufacturing Engineering	I	ME	Manufacturing Engineering	CP	Core Practical
5	EE	Electrical Engineering	I	PS	Power System Engineering	TS	Industrial Training and Seminar
6	EI	Electronics & Instrumentation Engineering	I	PC	Process Control & Instrumentation	PV	Project work & Viva-voce
7	CH	Chemical Engineering	I	CE	Chemical Engineering	MC	Mandatory Learning Course
			II	FT	Food Processing Technology		
8	CS	Computer Science and Engineering	I	CS	Computer Science and Engineering	AC	Audit Course

S. No	3rd & 4th Digits	DETAILS		5th & 6th Digits	DETAILS	7th & 8th Digits	DETAILS
9	EC	Electronics & Communication Engineering	I	CS	Communication Systems		
10	YY	Name of the Department					
11	ZZ	Name of the Program					

The first two digits relate to the year from which the Regulations commence
9th digit represents the semester and 10th digit represents the serial number of courses.
YY and ZZ relates to the Open Elective where YY corresponds to Name of the Department and ZZ to Name of the Program.

FACULTY OF ENGINEERING AND TECHNOLOGY

VISION

Providing world class quality education with strong ethical values to nurture and develop outstanding professionals fit for globally competitive environment.

MISSION

- Provide quality technical education with a sound footing on basic engineering principles, technical and managerial skills, and innovative research capabilities.
- Transform the students into outstanding professionals and technocrats with strong ethical values capable of creating, developing and managing global engineering enterprises.
- Develop a Global Knowledge Hub, striving continuously in pursuit of excellence in Education, Research, Entrepreneurship and Technological services to the Industry and Society.
- Inculcate the importance and methodology of life-long learning to move forward with updated knowledge to face the challenges of tomorrow.

DEPARTMENT OF ELECTRICAL ENGINEERING

VISION

To develop the Department into a “Centre of Excellence” with a perspective to provide quality education and skill-based training with state of the art technologies to the students, thereby enabling them to become achievers and contributors to the industry, society and nation together with a sense of commitment to the profession.

MISSION

M1: To impart quality education in tune with emerging technological developments in the field of Electrical and Electronics Engineering.

M2: To provide practical hands-on-training with a view to understand the theoretical concepts and latest technological developments.

M3: To produce employable and self-employable graduates.

M4: To nurture the personality traits among the students in different dimensions emphasizing the ethical values and to address the diversified societal needs of the Nation

M5: To create futuristic ambiance with the state of the art facilities for pursuing research.

PROGRAM EDUCATIONAL OBJECTIVES (PEO)

The core objectives of the M.E. Program 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 behavior in chosen career.

PEO-5: To engage actively in executing projects in multidisciplinary environment for the benefit of society.

PROGRAM OUTCOMES (POs)

After the successful completion of M.E (Power System Engineering) Program the students will be able to:

PO1: Scholarship of Knowledge

Acquire in-depth knowledge of specific discipline or professional area, including wider and global perspective, with an ability to discriminate, evaluate, analyse and synthesise existing and new knowledge, and integration of the same for enhancement of knowledge.

PO2: Critical Thinking

Analyse complex engineering problems critically, apply independent judgement for synthesising information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.

PO3: Problem Solving

Think laterally and originally, conceptualise and solve engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.

PO4: Research Skill

Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyse and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in one or more domains of engineering.

PO5: Usage of modern tools

Create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering activities with an understanding of the limitations.

PO6: Collaborative and Multidisciplinary work

Possess knowledge and understanding of group dynamics, recognise opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.

PO7: Project Management and Finance

Demonstrate knowledge and understanding of engineering and management principles and apply the same to one's own work, as a member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after consideration of economical and financial factors.

PO8: Communication

Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.

PO9: Life-long Learning

Recognise the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.

PO10: Ethical Practices and Social Responsibility

Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society

PO11: Independent and Reflective Learning

Observe and examine critically the outcomes of one's actions and make corrective measures subsequently, and learn from mistakes without depending on external feedback.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1:

Enable the student to acquire knowledge in Power System Engineering and imbibe the artifacts of related simulation tools.

PSO2:

Able to carry out research / investigate and to develop innovative methodologies independently to solve Power System problems.

PSO3:

Ensure a degree of mastery over the area of Power System Engineering with the exposure to the state of the art practices in the domain of Electric Power System Engineering and exhibit Professional intellectual integrity.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
PEO 1	3	3	3	3		2					2	2	1	2
PEO 2	3	3	3	3	3					1		3	2	3
PEO 3	3	3	3	3	3						3	3		2
PEO 4						2	2	3	1	2	3			1
PEO 5					2	2	2	2	3	2	3		3	2

CURRICULUM – 2023

M.E (POWER SYSTEMS ENGINEERING)

SEMESTER I									
Course Code	**Category**	**Course**	**L**	**T**	**P**	**CA**	**FE**	**Total**	**Credits**
23EEPSPC11	**PC**	Digital Simulation of Power Systems	3	-	-	25	75	100	3
23EEPSPC12	**PC**	Power System Operation and Control	3	-	-	25	75	100	3
23EEPSPE13	**PE**	Program Elective – I	3	-	-	25	75	100	3
23EEPSPE14	**PE**	Program Elective – II	3	-	-	25	75	100	3
23EEPSMC15	**MC**	Research Methodology and IPR	2	-	-	25	75	100	2
23EEPSCP16	**CP**	Advanced Power System Analysis Lab	-	-	4	40	60	100	2
23EEPSCP17	**CP**	Advanced Renewable Energy Lab	-	-	4	40	60	100	2
23EEPSAC18	**AC**	Audit Course – I	2	-	-	-	-	-	0
					Total	**205**	**495**	**700**	**18**

SEMESTER II									
Course Code	**Category**	**Course**	**L**	**T**	**P**	**CA**	**FE**	**Total**	**Credits**
23EEPSPC21	**PC**	Power System Stability	3	-	-	25	75	100	3
23EEPSPC22	**PC**	Power System Protection	3	-	-	25	75	100	3
23EEPSPE23	**PE**	Program Elective - III	3	-	-	25	75	100	3
23EEPSPE24	**PE**	Program Elective - IV	3	-	-	25	75	100	3
23YYZZOE25	**OE**	Open Elective - I	3	-	-	40	60	100	3
23EEPSCP26	**CP**	Power System Protection Lab	-	-	4	40	60	100	2
23EEPSTS27	**TS**	Industrial Training and Seminar / Mini project *	-	Tr 2	S 2	40	60	100	2
23EEPSAC28	**AC**	Audit Course - II	2	-	-	-	-	-	0
					Total	**205**	**495**	**700**	**19**

<table>
<tr><th colspan="11">SEMESTER III</th></tr>
<tr><th>Course Code</th><th>Category</th><th>Course</th><th>L</th><th>T</th><th>P</th><th>CA</th><th>FE</th><th>Total</th><th>Credits</th></tr>
<tr><td>23EEPSPE31</td><td>PE</td><td>Program Elective - V</td><td>3</td><td>-</td><td>-</td><td>25</td><td>75</td><td>100</td><td>3</td></tr>
<tr><td>23YYZZOE32</td><td>OE</td><td>Open Elective - II</td><td>3</td><td>-</td><td>-</td><td>25</td><td>75</td><td>100</td><td>3</td></tr>
<tr><td rowspan="2">23EEPSTH33</td><td rowspan="2">TH - I</td><td rowspan="2">Thesis Phase - I and Viva - voce</td><td rowspan="2"></td><td>Pr</td><td>S</td><td rowspan="2">40</td><td rowspan="2">60</td><td rowspan="2">100</td><td rowspan="2">10</td></tr>
<tr><td>16</td><td>4</td></tr>
<tr><td>23EEPSMC34</td><td>MC</td><td>Mandatory Course</td><td>3</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td colspan="6" align="right">Total</td><td>90</td><td>210</td><td>300</td><td>16</td></tr>
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<tr><th colspan="10">SEMESTER IV</th></tr>
<tr><th>Course Code</th><th>Category</th><th>Course</th><th>L</th><th>T</th><th>P</th><th>CA</th><th>FE</th><th>Total</th><th>Credits</th></tr>
<tr><td rowspan="2">23EEPSTH41</td><td rowspan="2">TH-II</td><td rowspan="2">Thesis Phase-II and Viva- voce</td><td rowspan="2">-</td><td>Pr</td><td>S</td><td rowspan="2">40</td><td rowspan="2">60</td><td rowspan="2">100</td><td rowspan="2">15</td></tr>
<tr><td>24</td><td>6</td></tr>
<tr><td colspan="6" align="right">Total</td><td>40</td><td>60</td><td>100</td><td>15</td></tr>
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Note: * - Four weeks during the summer vacation at the end of II Semester.
L: Lecture, P: Practical, T: Thesis, CA: Continuous Assessment; FE: Final Examination

PE - PROGRAM ELECTIVE COURSES

FIRST SEMESTER

23EEPSPEXX	-	STATE ESTIMATION AND SECURITY ASSESSMENT OF POWER SYSTEMS
23EEPSPEXX	-	WIND AND SOLAR SYSTEMS
23EEPSPEXX	-	EXTRA HIGH VOLTAGE AC AND DC TRANSMISSION
23EEPSPEXX	-	POWER SYSTEM PLANNING AND MANAGEMENT
23EEPSPEXX	-	SYSTEM THEORY
23EEPSPEXX	-	SOFT COMPUTING TECHNIQUES

SECOND SEMESTER

23EEPSPEXX	-	OPERATION OF RESTRUCTURED POWER SYSTEMS
23EEPSPEXX	-	SMART GRID
23EEPSPEXX	-	POWER SYSTEM DYNAMICS
23EEPSPEXX	-	ELECTRIC POWER DISTRIBUTION SYSTEM
23EEPSPEXX	-	SOLID STATE DRIVES
23EEPSPEXX	-	POWER SYSTEM TRANSIENTS
23EEPSPEXX	-	INSULATION TECHNOLOGY AND HIGH VOLTAGE ENGINEERING

THIRD SEMESTER

23EEPSPEXX	-	FACTS AND CUSTOM POWER DEVICES
23EEPSPEXX	-	POWER QUALITY
23EEPSPEXX	-	INDUSTRIAL LOAD MODELING AND CONTROL
23EEPSPEXX	-	BIG DATA ANALYTICS IN ELECTRIC POWER SYSTEMS
23EEPSPEXX	-	POWER SYSTEM SIGNAL PROCESSING FOR SMART GRIDS

23EEPSPEXX - POWER SYSTEM RELIABILITY
23EEPSPEXX - POWER SYSTEM INSTRUMENTATION
23EEPSPEXX - HIGH VOLTAGE TESTING TECHNIQUES

OE-OPEN ELECTIVE COURSES

23YYZZOEXX - ENERGY MANAGEMENT AND AUDIT
23YYZZOEXX - WASTE TO ENERGY
23YYZZOEXX - SCADA SYSTEM AND APPLICATIONS
23YYZZOEXX - NON CONVENTIONAL ENERGY ENGINEERING

AC-AUDIT COURSES

23EEPSACXX - ENGLISH FOR RESEARCH PAPER WRITING
23EEPSACXX - DISASTER MANAGEMENT
23EEPSACXX - SANSKRIT FOR TECHNICAL KNOWLEDGE
23EEPSACXX - VALUE EDUCATION
23EEPSACXX - PEDAGOGY STUDIES
23EEPSACXX - STRESS MANAGEMENT BY YOGA
23EEPSACXX - PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS

MANDATORY COURSES

23EEPSMCXX - CONSTITUTION OF INDIA

SEMESTER I

23EEPSPC11	DIGITAL SIMULATION OF POWER SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To introduce the basic studies in the area of power systems.
- To gain knowledge about the solution of network equation using sparsity techniques.
- To understand the various methodologies involved in the power flow studies
- To impart knowledge about the various short circuit studies in power system analysis.
- To familiarize with the concepts and solution methodologies involve in the power system stability studies.

INTRODUCTION

Importance of basic power system studies (power flow, short circuit and stability) in the planning and operation of power system - Distinction between steady state, quasi steady state and transient modelling of power system.

SPARSITY ORIENTED NETWORK SOLUTION

Solution of network equation - Exploiting sparsity of bus admittance matrix - Compact storage, optimal ordering, triangular factorization and solution using the factors - Solution using Gaussian elimination.

POWER FLOW STUDIES

Power flow model using bus admittance matrix - Fast decoupled power flow method (FDPF) - with voltage controlled buses using sparsity technique - Load flow based on sparsity oriented solution of I = YV - AC/DC power flow analysis using sequential FDPF method - Radial System power flow - Current injection based techniques - Multiarea power flow analysis with tie-line control - Special Purpose Power Flow Studies - Harmonic power flow - Three phase load flow - Distribution power flow - Interactive load flows - Contingency analysis - Sensitivity analysis.

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 - Use of sparse factors of YBUS for obtaining the columns of ZBUS.

STABILITY STUDIES

Mathematical model for stability analysis of a multi-machine system with exciters and governors - solution of state equation by modified Euler method / 4th order R.K. method.

TEXT BOOKS

1. Stagg G.W and El- Abiad .A.H, "Computer Methods in Power System Analysis", Medtech Scientific International Pvt. Ltd., Krieger Publishing Co., USA, 2019.
2. Pai M.A and Dheeman Chatterjee, "Computer Techniques in Power System Analysis", McGraw Hill (India) Pvt. Ltd., New Delhi, 2016.

REFERENCE BOOKS

1. L.P.Singh, "Advanced Power System Analysis and Dynamics", Revised 5th Edition, New Age International (P) Ltd. Publishers, New Delhi, 2014.
2. Arrillaga .J and Watson N R, "Computer Modelling of Electrical Power Systems" John Wiley and Sons, 2006
3. Kusic.G.L, "Computer Aided Power System Analysis", CRC Press, Boca Raton, 2009.
4. Heydt. T, "Computer Techniques in Power System Analysis", Macmillan USA 1996

COURSE OUTCOMES

At the end of the course work the students will be able to

1. Understand the basic studies in the area of Power Systems
2. Enable the effective use of computers for large power networks
3. Estimate the system state using power flow models
4. Offer to build power system models for different types of studies
5. Evaluate the stability of the system

Mapping with Program Outcomes														
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3													
CO2	3		2											
CO3	3	2	3	3	2				2			3		2
CO4	3	2	3	3	2				2			3		2
CO5	3	2	3	2	2				2			3		2

23EEPSPC12	POWER SYSTEM OPERATION AND CONTROL	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To learn the characteristics and bring out the need for operating the power plants in a viable and affordable manner.
- To develop methods for the optimum operation of the participating plants.
- To emphasize on the scheduling of the hydro and thermal plants.
- To bring out the significance of unit commitment based operation.
- 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

Characteristics of steam plants - Characteristics of hydro plants - Analytical form for input - Output characteristics of thermal units - Constraints in operation-Economic load dispatch neglecting transmission losses - Lambda iteration method - Derivation of transmission loss formula - Economic load dispatch with transmission losses - Gradient methods of economic dispatch- Newton'smethod.

OPTIMAL POWER FLOW

Optimal power flow - Problem statement and formulation - Solution of opf- Gradient method - newton‘s method - Linear sensitivity analysis - Linear programming method - Security constrained optimal power flow - Interior point algorithm.

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

Unit commitment problem - Spinning reserve - thermal unit constraints - Hydro constraints- Fuel Constraints - Solution methods - Priority List method - Dynamic programming method - Lagrangian Relaxation method.

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

1. Wood and Wollenberg, 'Power Generation, Operation and Control', John Wiley and Sons, 2013.
2. Das. D, "Electrical Power Systems‖, New Age International Publishers", New Delhi, 2009.
3. Murthy P.S.R, "Operation and Control in power systems‖", Tata McGraw Hill, 2009.
4. Kothari D.P and Dhillon J.S, "Power System Optimization", Prentice Hall of India, New Delhi, 2010.
5. JiZhong Zhu, "Optimization of Power System Operation", Wiley IEEE Press, New Jersey, 2009.
6. Kirchmayer, " Economic Operation of PowerSystems"2009
7. Elgerd.O.I, "Electric Energy Systems: Theory – An Introduction", Tata McGraw Hill, New Delhi, 2001.

COURSE OUTCOMES

At the end of the course work the students will be able to

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.

Mapping with Program Outcomes														
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	1										3	1
CO2	3	2	1		1								3	2
CO3	3	2	1	1						1			3	2
CO4	3	2	1	1						1			3	2
CO5	3	2	1		2					1			2	2

23EEPSMC15	RESEARCH METHODOLOGY AND IPR	L	T	P	C
		2	0	0	2

COURSE OBJECTIVES

- To gain a sound knowledge of scientific research for undertaking a valid study
- To explore the techniques ofdefining aresearchproblem and investigate the various research designs, highlighting their main characteristics
- To understand the ethical issues of writing technicalpapers
- To provide an insight on intellectual property
- To address new and international developments in IPR.

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Effective literature studies approaches, analysis - Plagiarism, Research ethics Effective technical writing, how to write report, Paper - Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT

Patent Rights: Scope of Patent Rights - Licensing and transfer of technology - Patent information and data bases - Geographical Indications - New Developments in IPR: Administration of Patent System - New developments in IPR; IPR of Biological Systems, Computer Software etc - Traditional knowledge Case Studies, IPR and IITs.

REFERENCES

1. Stuart Melville and Wayne Goddard, “Research methodology: an Introduction for Science & Engineering students”, Juta Academic, 1996
2. Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”, Juta Academic, 2004
3. Ranjit Kumar, “Research Methodology: A Step-by-Step Guide for beginners”, Sage Publications Ltd, 2014.
4. Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd, 2007.
5. Mayall, “Industrial Design”, McGraw Hill, 1992.

6. Niebel, “Product Design”, McGraw Hill, 1974.
7. Asimov, “Introduction to Design”, Prentice Hall, 1962.
8. Robert P. Merges, Peter S. Menell, Mark A. Lemley, “Intellectual Property in New Technological”, Age, 2016.
9. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008

COURSE OUTCOMES

At the end of the course work the students will be able to

1. Understand research problem formulation.
2. Analyze research related information and Follow research ethics
3. Understand that today‘s world is controlled by Computer, Information Technology, but tomorrow’s worldwillberuledbyideas, concept, andcreativity.
4. Understand that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
5. Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

Mapping with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2		3			3	2					2	
CO2	3	2	2	3		3	3	2		3		3	2	
CO3	3	3	2	3	2		2			3		3	2	
CO4	3	3		3		2	3			3		3	2	3
CO5	3	2	3	2	2	3	2	1		2		3	1	3

23EEPSCP16	ADVANCED POWER SYSTEM ANALYSIS LAB	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES

- To understand and learn the relative theory involved in the power system analysis
- To build up appropriate methodology for articulation of the algorithm implementation
- To set-up the coding the methodology evolved for executing the experiment.
- To carry out / employ the methodology
- To surmise / arrive at inferences from the results

LIST OF EXPERIMENTS

1. Formation of bus admittance and impedance matrices
2. Load flow study based on Gauss - Seidal method
3. Load flow study based on Newton-Raphson method
4. Load flow study based on Fast Decoupled Load flowmethod
5. DC load flowanalysis
6. Contingency analysis
7. State estimation based on WLSE method
8. Economic load dispatch
9. Optimal power flow analysis
10. Load frequency control of single area system
11. Load frequency control of two area system
12. Symmetrical short circuit study
13. Unsymmetrical short circuit study
14. Economic load dispatch based on B_{mn} co-efficient
15. Transient stability analysis
16. Voltage stability study

COURSE OUTCOMES

At the end of the course work the students will be able to

1. Learn the relative theory involved in the power system analysis
2. Develop the appropriate methodology for articulation the algorithm implementation
3. Contrivance the coding the methodology evolved for executing the experiment
4. Execute / implement the methodology
5. Infer / arrive at inferences from the results

Mapping with Program Outcomes														
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**	**2**	**2**		**2**							**3**		**3**
CO2	**2**		**2**		**3**							**3**		**3**
CO3	**3**	**2**	**2**		**3**							**2**		**3**
CO4	**3**	**2**	**2**		**3**				**1**		**1**	**2**		**3**
CO5	**2**		**2**		**3**							**3**	**2**	**2**

23EEPSCP17	ADVANCED RENEWABLE ENERGY LAB	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES

- To understand and learn the relative theory involved in the power system analysis
- To build up appropriate methodology for articulation of the algorithm implementation
- To set-up the coding the methodology evolved for executing the experiment.
- To carry out / employ the methodology
- To surmise / arrive at inferences from the results

LIST OF EXPERIMENTS

1. a) Design of equivalent circuit parameters of a solar cell.
   b) Determination of V- I and P -V characteristics of a solar cell.
2. Determination of MPPT of a solar energy conversion system
3. Characteristics of the solar array using simulator.
4. Performance evaluation of a DC Transmission line fed from a solar energy source.
5. a) Determination MPPT of wind energy conversion system.
   b) Determination of characteristics of PMSG driven wind turbine
6. Power quality measurement for RLC load using power quality analyzer.
7. Cost estimation of a solar PV energy conversion system.
8. Cost estimation of wind turbine.
9. Cost estimation of biogas plant
10. P-V and I-V characteristics of PV array using MATLAB simulation.
11. Perturb and Observe method of MPPT simulation for solar PV system
12. Modelling of wind turbine using MATLAB simulation
13. Characteristics of wind energy conversion systems using MATLAB simulation.
14. Prediction of wind speed by Fuzzy Logic Controller using MATLAB simulation
15. Simulink model of grid connected wind power system
16. Simulation study of hybrid (solar /wind/ Diesel) power system using MATLAB

COURSE OUTCOMES

At the end of the course work the students will be able to

1. Learn the relative theory involved in the power system analysis
2. Develop the appropriate methodology for articulation the algorithm implementation
3. Contrivance the coding the methodology evolved for executing the experiment
4. Execute / implement the methodology
5. Infer / arrive at inferences from the results

Mapping with Program Outcomes														
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2			2	2		1	1	1	3		
CO2	3	2	2			2	2		1	1	1	3		
CO3	3	3	3	3		2	2		1	1	2	3	2	
CO4	3	2	2	2		2	2		1	1	2	3	2	
CO5	3	3	3	3	3	2	2		1	1	3	3	3	

SEMESTER II

23EEPSPC21	POWER SYSTEM STABILITY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To distinguish between the different types of power system stability studies
- To understand the concept of small signal stability
- To study the various solution methodologies for transient stability analysis
- To analyze the voltage stability assessment methods
- To gain knowledge about the various method involved in improving the power system stability

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.

SMALL SIGNAL STABILITY

State space representation - Eigen values - Modal matrices - Synchronous machine classical model representation - Small signal stability of single machine connected to infinite bus system - Effect of field circuit dynamics - Effect of excitation system - Small signal stability of multi machine system - Small signal stability enhancement methods.

TRANSIENT STABILITY ANALYSIS

Distinction between transient and dynamic stability - An elementary view of the transient stability problem - Assumptions made in stability studies - Equal area criterion to test the transient stability of simple power systems - Calculation of critical clearing angle and clearing time - Limitations of equal area criterion. Factors influencing transient stability - Review of numerical integration methods - Modified Euler‘s method and 4th order Runge - Kutta method.

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.

METHODS OF IMPROVING STABILITY

Transient stability enhancement - Steam turbine fast valving - High speed excitation systems - High speed fault clearing - Single pole switching - Independent pole operation of circuit breakers -

Generator tripping. Small signal stability enhancement - PSS - Selection of PSSlocation

REFERENCES

1. Kundur P, “Power System Stability and Control”, McGraw Hill Education, 2006.
2. Taylor C W, “Power System Voltage Stability”, McGraw Hill, Inc., 1994.
3. Miller T.J.E, “Reactive power control in electric systems”, Wiley India, 2010.
4. Anderson P.N, Fouad, A.A, “ Power system control and stability”, Wiley India, 2008.
5. Sauer P W and Pai M A, “Power System Dynamics and Stability”, Pearson, 2003.

COURSE OUTCOMES

At the end of the course work the students will be able to

1. Familiarize with the different types of stability in power systems.
2. Understand the significance about small signal stability analysis and its enhancement.
3. Gain knowledge on Transient stability analysis
4. Know the significance of voltage stability analysis.
5. Investigate the various methods to enhance transientstability

Mapping with Program Outcomes														
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**	**2**										**3**		**3**
CO2	**3**	**2**		**2**					**2**			**2**		**2**
CO3	**3**	**2**	**2**	**2**					**2**			**2**		**2**
CO4	**3**	**2**	**2**	**2**					**2**			**2**		**2**
CO5	**2**								**2**			**2**		**1**

23EEPSPC22	POWER SYSTEM PROTECTION	L	T	P	C
		3	0	0	3

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 onGenerator and Induction Motor Protection
- To introduce the automation of substation

OVERCURRENT PROTECTION

Introduction-need for protective systems - Evolution of digital relays from electromechanical relays - Primary and back-up protection - Protection schemes - Over Current protection-types of over current relay- Over current protective schemes- Directional protection– 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 - Basic elements of digital protection

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- Digital Differential Protection of Transformers

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 - Digital Line Differential Protection

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 - Recent Advances in Digital Protection of Power Systems.

REFERENCES

1. Y.G. Paithankar and S.R Bhide, “Fundamentals of Power System Protection”, Prentice-Hall of India, 2013.
2. Badri Ram and D.N Vishwakarma, “Power System Protection and Switchgear”, Tata McGraw Hill Education Private Limited, 2011.
3. Alstom, “Network Protection & Automation Guide”, 2011
4. Juan M. Gers and Edward J. Holmes, “Protection of Electricity Distribution Networks”, The Institution of Engineering and Technology, 2011
5. C. Christopoulos and A.Wright, “Electrical power system protection”, Springer, 2013
6. S.R.Bhide “Digital Power System Protection” PHI LearningPvt.Ltd.2014

COURSE OUTCOMES

At the end of the course work the students will be able to

1. Obtain fundamental knowledge about various protection schemes including over current protection.
2. Become proficient in incorporating transformer protection schemes.
3. Gain familiarity in several protection schemes for transmission lines.
4. Acquire knowledge in designing various kinds of Generator and Motor Protection
5. Familiarize with the substation automation.

Mapping with Programme Outcomes															
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	2					2					3		
CO2	3	2	2					2					2	2	
CO3	3	2	2					2			2		2	2	
CO4	3	3	3	2				2		2	2		3	2	2
CO5	3	3	3	2				2	3	3	2		3	2	2

23EEPSCP26	POWER SYSTEM PROTECTION LAB	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES

- To understand and learn the relative theory involved in the power system analysis
- To build up appropriate methodology for articulation of the algorithm implementation
- To set-up the coding the methodology evolved for executing the experiment.
- To carry out / employ the methodology
- To surmise / arrive at inferences from the results

LIST OF EXPERIMENTS

1 Time/Current Characteristics of IDMT Over Current Relay (Electro Mech Type)
2 Time/Voltage Characteristics of Over Voltage Relay (Electro Mech Type)
3 Time/Voltage Characteristics of Under Voltage Relay (Electro Mech Type)
4 Time/Current Characteristics of earth Fault Relay Testing Kit (Electro Mech Type)
5 Time/Current Characteristics of Directional Over Current and Earth Fault Relay (Electro Mech Type)
6 Time/Current Characteristics of Directional Over Current Relay (Numerical)
7 Time/Current Characteristics of Percentage Based Differential Relay (Static Type)
8 Under and Over Voltage Protection Scheme for Power Transformer.
9 Phase failure testing scheme for Power Transformer.
10 Phase Reversal testing scheme for Power Transformer.
11 Current differential relay testing scheme for Power Transformer.
12 Buchholz relay testing scheme for Power Transformer.
13 Simulation of Earth fault testing scheme for feeder connected in the LT side of Power Transformer.
14 Simulation of Short circuit testing scheme for feeder connected in the LT side of Power Transformer.
15 Simulation of Motor Protection scheme used in the LT side of Power Transformer.
16 Simulation of Feeder Protection scheme coupled with Power Transformer.
17 Earth fault testing scheme for feeder connected in the LT side of Power Transformer.
18 Short circuit testing scheme for feeder connected in the LT side of Power Transformer.
19 Motor Protection scheme used in the LT side of Power Transformer.
20 Protection scheme for a Feeder coupled with Power Transformer

COURSE OUTCOMES

At the end of the course work the students will be able to

1. Learn the relative theory involved in the power system protection
2. Develop the appropriate methodology for articulation the algorithm implementation
3. Contrivance the coding the methodology evolved for executing the experiment

4. Execute / implement the methodology
5. Infer / arrive at inferences from the results

Mapping with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3										3	2	
CO2	3	3			3							2	3	
CO3	3	3			3							2	3	
CO4	3	3			3							3	3	
CO5	3	3			3							3	3	

23EEPSTS27	INDUSTRIAL TRAINING AND SEMINAR / MINI PROJECT	L	Tr	S	C
		0	2	2	2

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.
- 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.

Each student should individually undergo a training program in reputed industries 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/she had, within ten days from the commencement of the third semester for Full-time / fifth semester for part-time. The student will be evaluated, by a team of staff members nominated by Head of the department, through a viva-voce examination.

Further, each student will work for two periods per week guided by student counsellor. He/she 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 and will defend the presentation. A brief copy of the 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

At the end of the course work the students will be able to

1. Face the challenges in the fieldwithconfidence.
2. Benefit by the training with managing the situation that arises during the execution of works related to Power Systems.
3. Get the training to face the audience and to interact with the audience with confidence.
4. Tackle any problem during group discussion in the corporate interviews.
5. Gain practical knowledge in carrying out Power Systems field related works.

Mapping with Program Outcomes														
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2		2		2			1		1	2		2
CO2	2			2		2	2		1			2	2	2
CO3				2		2		2	1	2	1	2	1	1
CO4						2			2	2	1		1	1
CO5	2	2	2			2	2	2	2			1		1

SEMESTER III

		L	Pr	S	C
23EEPSTH33	**THESIS PHASE-I AND VIVA-VOCE**	**0**	**16**	**4**	**10**

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

1. The student undergoes literature survey and identifies the topic of thesis and finalizes in consultation with Guide/Supervisor and prepares a comprehensive thesis report after completing the work to the satisfaction of the supervisor.
2. The progress of the thesis is evaluated based on a minimum of three reviews.
3. The review committee will be constituted by the Head of the Department.
4. A thesis report is required at the end of the semester.
5. 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

At the end of the course work the students will be able to

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

Mapping with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3			1				1			1	1	2	
CO2	3	2	3	2	2			2				1		
CO3	2	1		1	1					1	2	2	1	
CO4	3			2				2		1	3			2
CO5	2			2				2		2				1

SEMESTER IV

23EEPSTH41	THESIS PHASE-II AND VIVA-VOCE	L	Pr	S	C
		0	24	6	15

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

1. The progress of the thesis is evaluated based on a minimum of three reviews.
2. The review committee will be constituted by the Head of the Department.
3. A thesis report is required at the end of the semester.
4. 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

At the end of the course work the students will be able to

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.

Mapping with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3											3		
CO2	3	3	3	3							2	2		
CO3	2			1	3							1		1
CO4	3							2		3			3	
CO5	2							2		3				3

PROGRAM ELECTIVE COURSES
SEMESTER I

23EEPSPEXX	STATE ESTIMATION AND SECURITY ASSESSMENT OF POWER SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES
- To acquire fundamental knowledge in power system state estimation
- To gain knowledge in distribution system stateestimation
- To perform observability analysis in the power system networks
- To learn the techniques that enable estimating the system state in distribution systems.
- To gather knowledge on power system state estimation and strategies to enhance the secure power system operations.

INTRODUCTION
State estimation - Energymanagement 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.

POWER SYSTEM STATE ESTIMATION
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.

NETWORK OBSERVABILITY ANALYSIS
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.

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

1. Ali Abur, "Power System State Estimation Theory and Implementation", Marcel Dekker, 2004.
2. A.J. Wood, B.F. Wollenberg and G.B. Sheble," Power Generation, operation and Control", John Wiley and Sons, 3rd Edition, 2013.
3. Mahalanabis, Kothari and Ahson, "Computer Aided Power System Analysis and Control", Tata McGraw Hill Publishers, 1991.
4. Abhijit Chakrabarti and Sunita Halder, " Power System Analysis Operation and Control", PHI Learning, 2010.
5. G.L. Kusic, "Computer Aided Power System Analysis", Prentice Hall of India, 1989.
6. Davide Della Giustina, Marco Pau, Paolo AttilioPegoraro, Ferdinanda Ponci and Sara Sulis**, "** Electrical Distribution System State Estimation: Measurement Issues and Challenges", IEEE Instrumentation & Measurement Magazine, 2014.

COURSE OUTCOMES

At the end of the course work the students will be able to

1. Understand the conceptual aspects in power system state estimation.
2. Demonstrate various state estimation methods.
3. Acquire proficiency to perform observability analysis.
4. Conduct distribution state estimation.
5. Realize the security assessment and enhancementstrategies.

Mapping with Programme Outcomes														
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**													
CO2	**3**	**2**	**2**	**2**								**3**		**2**
CO3	**3**	**2**										**3**	**2**	**1**
CO4	**3**		**2**											**1**
CO5	**3**	**2**	**2**	**2**								**3**		**2**

23EEPSPEXX	WIND AND SOLAR SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To understand the concept of wind energy system
- To learn the operation of different types of wind driven generators
- To enable an insight into the wind power management schemes.
- To impart knowledge in solar energy system
- To offer a study on Solar Photovoltaic systems

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

Characteristics of Induction generators - Permanent magnet generators - Single phase operation of induction generators - Doubly fed generators - Grid connected and stand alone systems - Controllers for wind driven self excited systems and capacitor excited isolated systems - Synchronized operation with grid supply - Real and reactive power control.

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

Sun as source of energy - Availability of solar energy - Nature of solar energy - solar energy and environment - Various methods of using solar energy - solar thermal, photovoltaic, photosynthesis - present andfuture scope of solar energy.

Storage of solar energy - Types of energy storage - Thermal storage - Electrical storage - Chemical storage - Hydro storage - Solar ponds - Principle of operation of solar ponds - Application of solar ponds.

PHOTO VOLTAIC SYSTEM

Solar cells and panels - Structure of PV cells - semiconductor materials for PV cells - I-V characteristics of PV systems - PV models and equivalent circuits- effects of irradiance and temperature on PV characteristics .

A basic photo voltaic system for power generation - Advantages and disadvantages of photo voltaic solar energy conversion - Application of solar photo voltaic system - components of PV systems - Design of PV systems - Power conditioning and storage arrangement - Maximum power point tracking - Introduction to string inverters.

REFERENCES

1. G.D. Rai, "Non-conventional Energy Resources", Khanna Publishers, 2011.
2. G.N. Tiwari, Solar Energy: "Fundamentals, Design, Modeling & Application", Narosa Publishing House, 2013.
3. Siraj Ahamed, "Wind Energy": Theory & Practice PHI Learning Private Limited, 2010.
4. G.D. Rai, "Solar Energy Utilisation, Khanna Publishers", Fifth Edition, 2011.
5. B.H. Khan, "Non-conventional Energy Resources", Tata McGraw Hill, Second Edition, 2010.

COURSE OUTCOMES

At the end of the course work the students will be able to

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. Learn the basics of solar energy and its prospects.
5. Understand the basic knowledge of photo voltaicsystem.

Mapping with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2					2	2					2	2	1
CO2	3	3	2	2		2	2					2	2	1
CO3	3	2	2	2										
CO4	2	2	2			2	2					2		
CO5	3	2	2	2		2	2					2	2	1

23EEPSPEXX	EXTRA HIGH VOLTAGE AC AND DC TRANSMISSION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To understand the basics of extra high voltage AC and DC transmission.
- To learn about the properties of bundle conductors and voltage control using compensators.
- To gain knowledge about the types of HVDC transmission systems, their 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

EHV Testing - Standard specifications and standard wave shapes for testing Generation of switching surges for transformer testing - Impulse voltage generators - Generation of impulse currents - General layout of EHV laboratory. Over voltages in EHV systems - Origin and types - Switching surges - Lightning surges - Design of EHV Lines - Design factors under steady state-steady state limits - Line insulation coordination based upon transient over voltages - Design examples.

REFERENCES

1. Rakosh Das Begamudre, " Extra High Voltage AC Transmission Engineering", New Age International Pvt Ltd Publishers, 4th edition, 2014.
2. S. Rao, EHV-AC, "HVDC Transmission and Distribution Engineering", Khanna Publishers, 3rd edition, 2001.
3. Padiyar K.R., "HVDC Power Transmission Systems", New Age International Pvt Ltd; 3rd edition, 2015.
4. Kuffel and Zaengl, "High Voltage Engineering Fundamentals", Elsevier; 2rd edition, 2008.

COURSE OUTCOMES

At the end of the course work the students will be able to

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 testing, overvoltage and design of EHVsystem

Mapping with Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2													2
CO2	3	2										1		
CO3	2	2										2		3
CO4	1		3											2
CO5	2	2	3	3								2		2

23EEPSPEXX	POWER SYSTEM PLANNING AND MANAGEMENT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To understand the basic concepts of Power System Planning
- To familiarize Load Modelling, Forecasting and its impact in Demand Side Management
- To understand the basics of Renewable Energy Technologies in power system planning.
- To study about the need for Integrated Resource and its impact
- To gain the basic knowledge about Financing of Power Projects

INTRODUCTION TO POWER SYSTEM PLANNING

Factors affecting the future of power supply industry - Power system planning process objectives power system composition - The planning process power system planning - Electricity supply industry reform - Deregulation of markets - Public private partnership models - Environmental considerations - Other considerations affecting the power industry reform - Planning criteria - Planning expansion - Power system stability concerns - Modeling and performance indicators - Power quality (PQ) considerations - Uncertainty constraints and risk analysis planning - Generation expansion planning

LOAD MODELLING, FORECASTING AND DEMAND SIDE MANAGEMENT

Load research - Load research methodology - Driving factors - Load modeling - Electricity load forecasting - Classifications - Forecasting perspectives and forecasting driving factors - Forecasting time frames.- Energy efficiency - Impact on electricity consumption - Appliance efficiency building efficiency - Improving energy efficiency - Incentives mechanisms to effect energy efficiency. - Demand side management - Concepts and characteristics of demand side management (DSM) - Alternatives of DSM - Benefits of DSM implementation of DSM, evaluation of DSM alternatives

RENEWABLE ENERGY TECHNOLOGIES

Introduction - Re and electric power - Green energy and sustainable energy generation - Re pricing - Production economics - Environmental impacts - Promoting of re- system expansion studies - Generation expansion - Transmission and distribution expansion - Cost considerations and expansion obligations - Regulatory incentives

INTEGRATED RESOURCE PLANNING

Interconnected systems - AC and HVDC interconnection - Benefits of interconnection - Technical factors - Economic and financial impacts - Environmental concerns - Social impacts - Legal and political aspects - Integrated resource planning (IRP) - Concept and rationale - Supply and demand side interaction -Uncertainty and cost implications - Benefits of IRP,

FINANCING OF POWER PROJECTS

Introduction - Economic feasibility of projects - Factors influencing investment in power systems - Financial vs economic analyses - Financial analysis tools - Major factors influencing financing - Financing requirements - Public private partnership (PPP) - Tariff studies - Tariff calculation models - Social tariff impacts - Cost-reflective tariff - Regulations and tariffs -planning tools - Data collection - Group thinking - Decision support analysis - Decision aiding tools - Strategic planning

TEXT BOOK

1. Fawwaz Elkarmi, Nazih Abu-Shikhah, "Power System Planning Technologies and Applications: Concepts, Solutions and Management", Engineering Science Reference (an imprint of IGI Global), Pennsylvania, 2012.

REFERENCE BOOKS

1. Juergen Schlabbach and Karl-Heinz Rofalski, "Power System Engineering Planning, Design, and Operation of Power Systems and Equipment", WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, 2008
2. Hossein Seifi, Mohammad Sadegh Sepasian, "Electric Power System Planning: Issues, Algorithms and Solutions", Springer, Berlin, 2011.
3. Ning Zhang, Chongqing Kang, Ershun Du, Yi Wang, "Analytics and Optimization for Renewable Energy Integration (Energy Analytics)", First Edition, CRC Press, Boca Raton, 2019.
4. Ankita Sharma, "Power System Planning", Genius Publications, 5th Edn, Jaipur, 2019
5. J.Raja, P.Ajay D Vimal Raj, S.Rajasekar, "Practices in Power System Management in India", Springer, Singapore, 2018.
6. Tjernberg, Lina Bertling, "Infrastructure Asset Management with Power System Applications", CRC Press, 2018.

COURSE OUTCOMES

At the end of the course work the students will be able to

1. Learn the basic concepts of Power System Planning
2. Study in detail about the Load Modelling, Forecasting and its impact in Demand Side Management
3. Familiarize Renewable Energy Technologies in power system planning
4. Understand the need for Integrated Resource and its impact
5. Gain knowledge about Financing of Power Projects

Mapping with Program Outcomes														
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3										3		
CO2	3	2										3		
CO3	3	2										3		
CO4	3	3										3		
CO5	3	3										3		

23EEPSPEXX	SYSTEM THEORY	L	T	P	C
		3	0	0	3

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 and to get familiarized 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- sterilizability 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

1. Arthur G. O. Mutambara, “Design and Analysis of Control Systems”, CRC Press, Indian reprint, 2009.

2. M. Gopal, "Modern Control System Theory", New Age International, 2014.
3. Z. Bubnicki, "Modern Control Theory", Springer, 2005.
4. Graham C. Goodwin, Stefan F. Graebe and Mario E. Salgado, "Control system Design", PHI (Pearson), 2003.
5. D. Roy Choudhury, "Modern Control Systems", New Age International, 2005.

COURSE OUTCOMES

At the end of the course work the students will be able to

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 with modal control concepts.

Mapping with Program Outcomes														
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**	**3**	**3**	**2**								**2**		
CO2	**3**	**2**	**2**	**2**								**3**		
CO3	**3**	**2**	**2**	**2**								**2**		
CO4	**3**	**2**	**2**	**2**								**3**		**2**
CO5	**3**	**2**	**2**	**2**								**2**		**2**

23EEPSPEXX	SOFT COMPUTING TECHNIQUES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To familiarize the students with the various architectures and learning algorithms of Artificial Neural Network.
- To make the students to understand the basis of classifying neural networks and suitability for different applications.
- To enable the students to acquire knowledge about Competitive Neural Networks.
- To acquire the basic knowledge about Fuzzy logic and its applications.
- To gain knowledge about the need and usage of Evolutionary Algorithms.

ARTIFICIAL NEURAL NETWORKS

Motivation for the development of neural networks - Biological neural networks - Artificial neural networks - Fundamental Concepts - Weights - Biases and thresholds - Common activation functions. McCulloch-Pitts neuron: Architecture - Algorithm - Applications - Hebb Net - Architecture - Algorithm - Application - Perceptron - Architecture - Algorithm - Applications - Linear separability - Perceptron learning rule convergence theorem - Delta rule.

NEURAL NETWORK ARCHITECTURE AND ALGORITHMS

Back propogation Neural Net: Standard and counter back propogation - Architecture - Algorithm - Number of hidden layers - Applications - Hopfield neural net- Discrete and Continuous - Architecture - Algorithm - Applications - Associative Memory Neural Networks - Boltzman Machine.

COMPETITIVE NEURAL NETWORKS

Fixed -Weight competitive nets - Maxnet - Mexican Hat Net - Kohonen self-organizing Maps - Applications - Adaptive Resonance Theory - Basic architecture and operation - Neuro controllers - Functional diagram - Inverse dynamics - Coping control action - Case studies.

FUZZY LOGIC

Fuzzy sets - Properties of Classical and Fuzzy sets - Operations on Fuzzy sets - Fuzzy relations - Linguistic variables - Linguistic Hedges - Fuzzy statements - Assignment statements - Conditional statements - Unconditional statements - Fuzzy rule base - Canonical rule formation - Decomposition of compound rules.- Fuzzy logic controller: Functional diagram - Fuzzification - Membership value assignments using intuition - Membership functions - Defuzzification: Max-Membership principle - Centroid method - Weighted average method - Inference Engine - Knowledge Base - Rule base - Case studies

EVOLUTIONARY PROGRAMMING

Optimization - Traditional optimization methods - Concept of Evolutionary Algorithm - Simulated Annealing - Genetic Algorithm - Encoding and decoding of variables - GA operators - Reproductions - Cross over - Mutation - Fitness function - Fitness scaling - Real coded GA - Advanced operators - Particle swarm optimization.

REFERENCE BOOKS

1. Lawrence Faussett, ‘Fundamental of neural networks’, Prentice Hall, 2004.
2. Ross T.J, ‘Fuzzy Logic with Engineering Applications’, McGraw-Hill, New York, 2005.
3. David .E. Gold berg, ‘Genetic algorithms in search optimization and machine learning’, Addison Wesley, Pearson Education, Asia, 2001.
4. Driankov.Hellendoornarow D.H Reinfrank M, ‘An introduction to Fuzzy Control’, Narosa Publishing co., New Delhi, 1996.
5. Zurada J.M, ‘Introduction to Artificial Neural Systems’, Jaico Publishing House, Delhi, 2001.
6. Klir G.J. and Folger T.A, ‘Fuzzy sets, uncertainty and information’, Prentice Hall, 2004.
7. Simon Haykin, ‘Neural Networks’, Macmillan College Publishing co., New York, 1994.
8. Sivanandham. SN and Deepa, SN, ‘Neural networks with Matlab’, TMH 2007.

COURSE OUTCOMES

At the end of the course work, The students will be able to

1. Analyze the various learning algorithms of Artificial Neural Network
2. Recognize the merits and demerits of applying a particular ANN model for a particular problem.
3. Familiarize about the various Competitive Neural Networks
4. Design and apply fuzzy Logic based reasoning to handle uncertainty in engineering problems.
5. Gain knowledge about the various Evolutionary Programming

Mapping with Program Outcomes														
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**	**3**										**3**		
CO2	**3**	**2**										**3**		
CO3	**3**	**2**										**3**		
CO4	**3**	**3**										**3**		
CO5	**3**	**3**										**3**		

SEMESTER II

23EEPSPEXX	OPERATION OF RESTRUCTURED POWER SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To introduce the concept of deregulation and Economic operation of power system
- To impart knowledge on fundamental concepts Power System Operation in Competitive Environment
- To know about open access and pricing in transmission systems
- To gain knowledge about the AGC in Restructured Power System
- To understand the concepts of various types of ancillary services and reliability concepts

POWER SYSTEM RESTRUCTURING AND ECONOMIC OPERATION OVERVIEW

Introduction - Need for restructuring and deregulation - Different entities in deregulated electricity markets - Benefits from a competitive electricity market - After effects of deregulation - Economic load dispatch (eld) - ELD problem - Conditions for optimum ELD - Review of recent developments in ELD - Optimal power flow - The basic OPF model - Characteristic features of OPF - Unit commitment (UC) - The basic model of UC and its issues - Formation of power pools - power pools - The energy brokerage system

POWER SYSTEM OPERATION IN COMPETITIVE ENVIRONMENT

Introduction - Role of the independent system operator (Iso) - Structure of Uk and Nordic electricity sector deregulation - Operational planning activities of Iso - The iso in pool markets - The Iso in bilateral markets - Operational planning activities of a Genco - The Genco in pool markets - The Genco in bilateral markets - Market participation issues - Unit commitment in deregulated environment - competitive bidding

TRANSMISSION OPEN ACCESS AND PRICING ISSUES

Introduction - The us and the european perspective: TRANSCOS - Transmission system operator - Power wheeling - Transmission open access - Types of transmission services in open access - Cost components in transmission - Pricing of power transactions - Embedded cost based transmission pricing - Incremental cost based transmission pricing - Transmission open access and pricing mechanisms world wide - Security management in deregulated environment - Scheduling of spinning reserves - Interruptible load options for security management - Congestion management in deregulation - Economic instruments for handling congestion

AGC IN RESTRUCTURED POWER SYSTEM

Introduction - Traditional vs restructured scenario - AGC in new market environment - Block diagram and state space representation of a two-area interconnected power system in deregulated environment - Load-frequency control (LFC) dynamics and bilateral contacts - Modelling - Disco participation matrix (DPM)- Generation participation matrix (GPM).

ANCILLARY SERVICES MANAGEMENT AND RELIABILITY

Introduction to ancillary services - Ancillary services management worldwide - Check-list of ancillary services recognized by various markets - Reactive power as an ancillary services - Reactive power management in deregulated electricity markets - Synchronous generators as ancillary service providers - Reliability analysis - Effects on the actual reliability - Reliability costs-generation reliability - Transmission reliability- Distribution reliability - Regulation of the market - Performance indicators.

TEXT BOOK

1. Kankar Bhattacharya, Math H.J. Bollen, Jaap E. Daalder, Operation of Restructured Power Systems, Kluwer Academic Publishers, Boston , 2001
2. Loi Lei Lai, Power System Restructuring and Deregulation, John Wiley & Sons Ltd, London, 2001.

REFERENCE BOOKS

1. Joe H. Chow, Felix.F.Wu, James A. Momoh, “Applied Mathematics for Restructured Electric Power Systems: Optimization, Control, and Computational Intelligence”, Springer, New York, 2005.
2. S. C. Srivastava and S. N. Singh, “Operation and Management of Power system in Electricity Market”, Alpha Science, 2015.
3. S.A.Khaparde and A.R.Abhyankar, “Restructured Power Systems”, Narosa Publishing House, New Delhi, 2008.
4. Xiao-Ping Zhang, “Restructured Electric Power Systems: Analysis of Electricity Markets with Equilibrium Models”, John Wiley & Sons, New Jersey, 2010.
5. Das D, “Electrical Power Systems”, New Age International (P) Ltd, New Delhi- 2008.
6. Lorrin Philipson, H. Lee Willis, “Understanding Electric Utilities and De-Regulation”, 2nd Edition, CRC Press, Boca Raton, 2006.

COURSE OUTCOMES

At the end of the course work the students will be able to

1. Understand the concept of deregulation and Economic operation of power system
2. Gain knowledge about the fundamental concepts Power System Operation in Competitive Environment
3. Familiarize with the concept of open access and pricing in transmission systems
4. Acquire knowledge about the various types of ancillary services and reliability concepts
5. Acquaint about the AGC in Restructured Power System

Mapping with Program Outcomes														
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**	**2**		**2**					**2**			**3**		**2**
CO2	**3**	**2**		**2**					**2**	**2**		**3**		**2**
CO3	**3**	**2**		**2**					**2**	**2**		**3**		**2**
CO4	**3**	**2**		**2**					**2**			**3**		**2**
CO5	**3**	**2**		**2**					**2**	**2**		**3**		**2**

23EEPSPEXX	SMART GRID	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To familiarize with the fundamentals of smart grids and to get exposed to Smart Grid technologies, functionalities and capabilities
- To study about the load flow and contingency analysis in the smart grid
- To understand the various stability assessment tools for smart grid
- To focus on smart metering and demand-sideintegration
- To acquaint 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

Introduction to Stability - Strengths and Weaknesses of Existing Voltage Stability Analysis Tools - Voltage Stability Assessment - Voltage Stability Assessment Techniques - Voltage Stability Indexing - Analysis Techniques for Steady-State Voltage Stability Studies - Angle Stability Assessment

SMART METERING

Introduction - Smart metering - Comparison of Conventional and smart metering - Benefits of smart meters - Functional block diagram of a smart meter - stages in Smart meter architecture - Communication infrastructure and protocols for smart metering - Demand side integration.

FACTS AND ENERGY STORAGE IN THE SMART GRID

Introduction - Renewable energy generation - Fault current limiting - Shunt compensation - Series compensation - FACTS devices - HVDC- Energy storage - Applications and technologies.

TEXT BOOKS

1. I.S.Jha, Subir Sen, Rajesh Kumar, D.P.Kothari, "Smart Grid,Fundamentals & Application", New Age International (P) Limited, Publishers, New Delhi, 2019.
2. Ali Keyhani, "Design of Smart Power Grid Renewable Energy Systems", 3rd Edn, John Wiley & Sons, 2019.

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1. James Momoh, Smart Grid: "Fundamentals of Design and Analysis", (Wiley-IEEE Press), John Wiley & Sons, Inc., Hoboken, New Jersey, 2015.
2. Janaka Ekanayake, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, Nick Jenkins, "Smart Grid: Technology and Applications", Wiley, New Jersey, 2015.
3. Krzysztof (Kris) Iniewski, "Smart Grid Infrastructure & Networking", Tata McGraw Hill, 1st Edn, NewYork,2012.
4. Aranya Chakrabortty, Marija D. Ili´c, "Control and Optimization Methods for Electric Smart Grids", Springer New York, 2012.
5. Jennie C. Stephens, Elizabeth J. Wilson, Tarla Rai Peterson, "Smart Grid (R) Evolution Electric Power Struggles", Cambridge University Press, New York, 2015.
6. Bharat Modi, Anu Prakash, Yogesh Kumar, "Fundamentals of Smart Grid Technology", S.K. Kataria & Sons, New Delhi, 2015.
7. Mini S. Thomas, "Power System SCADA and Smart Grids", CRC Press, Boca Raton, 2015
8. Stuart Borlase, "Smart Grids Infrastructure, Technology and Solutions", CRC Press, London, 2013
9. A. B. M. Shawkat Ali, "Smart Grids: Opportunities, Developments and Trends", Springer-Verlag London 2013
10. Daphne Mah, Peter Hills, Victor O. K. Li, Richard Balme, "Smart Grid Applications and Developments", Springer-Verlag, London, 2014
11. Nouredine Hadjsaïd, Jean-Claude Sabonnadière, "Smart Grids", ISTE Ltd, London, 2012.
12. Adel Ali Abou El-Ela, Mohamed T, Mouwafi Adel A. Elbaset, "Modern Optimization Techniques for Smart Grids", Springer Nature Switzerland, 2022.

COURSE OUTCOMES

At the end of the course work the students will be able to

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

Mapping with Program Outcomes														
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**	**2**	**2**									**2**		
CO2	**3**	**3**	**2**	**2**	**2**		**2**				**2**	**2**	**3**	**2**
CO3	**3**	**2**		**2**							**2**	**2**		
CO4	**3**	**3**	**2**							**2**		**2**		**2**
CO5	**3**	**3**	**3**		**2**						**2**	**2**	**2**	**2**

23EEPSPEXX	POWER SYSTEM DYNAMICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To review the mathematical background of various power system utilities to construct efficient system model during various operating states.
- To understand the basics of dynamics and stability problems based on the modelling of s machines and controllers
- To familiarizes modelling of classical power plant components in detail
- To gain knowledge about the various existing techniques in the active power flow control for stability control of dynamic systems.
- To know about the various methodologies and remedial measures in ensuring a better reactive power flow control.

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 - Necessityforreduced models - Stabilityofinterconnected systems

MACHINE MODELLING AND MACHINE CONTROLLERS

Electromagnetic Model of Synchronous Generator - Park Equations - Modelling of the Induction Motor - Basic equations in the d–q Reference Frame - Steady-state operation of Synchronous generator and Induction Motor - Exciter and voltage regulator - Function of excitation systems - Typical excitation system configuration - Saturation function - Stabilizing circuit - Function of speed governing systems - Block diagram and state space representation of IEEE type excitation systems and IEEE mechanical hydraulic governor for hydro turbines and electrical hydraulic governors for steam turbines.

MODELLING OF CLASSICAL POWER PLANT COMPONENTS

Introduction - Gas turbines - Combined-cycle power plants - Types of turbines and governing systems for steam turbines - Model block diagrams - New thermal governor model - Modelling of hydro turbines and governor control systems - turbine conduit dynamics and controls - overview of wind turbines concepts - Fixed and variable-speed wind turbines - Modelling the wind turbine generators,- Constant-speed wind turbine- Doubly fed induction generator wind turbinesystem - DFIG Model.

ACTIVE POWER FLOW CONTROL

Small and large disturbances and deviations - UCTE load frequency control - Primary, secondary and tertiary control - System modelling, 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

Sensitivity coefficients - Voltage and reactive power control - Reactive power compensation - Grid voltage and reactive power control methods – automatic high- side voltage control in power plants - Grid hierarchical voltage regulation - Basic SVR and TVR Concepts - primary and secondary voltage regulation: architecture and modelling - Tertiary voltage regulation - Block diagram with the excitation system, analysis of effect of AVR on synchronizing and damping components.

REFERENCES

1. MirceaEremia, Mohammad Shahidehpour, "Handbook of Electrical Power System Dynamics, Modeling, Stability", and Control‖, IEEE Press - John Wiley & Sons, Inc., Hoboken, New Jersey, 2013.
2. Harry G. Kwatny, Karen Miu-Miller, "Power System Dynamics and Control: A Nonlinear Hybrid Systems Perspective", Springer New York, 2016.
3. Mohamed EL-Shimy, "Dynamic Security of Interconnected Electric Power Systems- Vol-2 - Dynamics and stability of conventional and renewable energy systems", Verlag Publishers, Deutschland, Germany, 2015.
4. Abhijit Chakrabarti, "Power System Dynamics and Simulation", PHI Learning Private Ltd, Delhi, 2015
5. R.Ramunujam, "Power System Dynamics Analysis and Simulation", PHI Learning Private Limited, New Delhi, 2010
6. K.Umarao, "Computer Techniques and Models in Power System", I.K. International, Second Edition, New Delhi 2014.
7. L.P.Singh, "Advanced Power System Analysis and Dynamics", New Age International (P) Ltd, Publishers, Fifth Edition, New Delhi, 2014.

COURSE OUTCOMES

At the end of the course work the students will be able to

1. Understand about various approaches in modelling of power system components and analyse for the dynamic operation of the power system
2. Adopt machine controllers for various machine models
3. Develop models for the Power Plant Components.
4. Arrive at methods for the control of Real Power
5. Evolve measures for controlling the Reactive Power

Mapping with Program Outcomes														
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**													
CO2	**3**		**2**	**2**								**3**		
CO3	**3**		**2**	**2**								**3**		**2**
CO4	**3**		**2**	**2**								**3**		**2**
CO5	**3**		**2**	**2**								**3**		**2**

23EEPSPEXX	ELECTRIC POWER DISTRIBUTION SYSTEM	L	T	P	C
		3	0	0	3

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

Technical and economical advantages of Microgrid-Challenges and disadvantages of Microgrid development-Management and operational issues of a Microgrid- -Impact on heat utilization-Impact on process optimization-Impact on market-Impact on environment-Impact on distribution system-Impact on communication standards and protocols. Microgrid economics-Main issues of Microgrid economics-Microgrids and traditional power system economics-Emerging economic issues in Microgrids-Economic issues between Micro grids and bulk power systems-Potential benefits of Microgrid economics

REFERENCES

1. Nick Jenkins, JanakaEkanayake , GoranStrbac , ―Distributed Generation‖, Institution of Engineering and Technology, London, UK,2010.
2. S. Chowdhury, S.P. Chowdhury and P. Crossley, ―Microgrids and Active Distribution Networks‖, The Institution of Engineering and Technology, London, United Kingdom, 2009.
3. Math H. Bollen , Fainan Hassan, ―Integration of Distributed Generation in the Power System‖, John Wiley &Sons, New Jersey, 2011.
4. Magdi S. Mahmoud, Fouad M. AL-Sunni, ―Control and Optimization of Distributed Generation Systems‖,Springer International Publishing, Switzerland, 2015.
5. NadarajahMithulananthan, Duong Quoc Hung, Kwang Y. Lee, ―Intelligent Network Integration of Distributed Renewable Generation‖, Springer International Publishing, Switzerland, 2017.
6. Ali K., M.N. Marwali, Min Dai, ―Integration of Green and Renewable Energy in Electric Power Systems‖, Wiley and sons, New Jersey, 2010.

COURSE OUTCOMES

At the end of the course work the students will be able to

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.

Mapping with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2			2	2				3	2	
CO2	3	3	2				2	2				3	2	2
CO3	3	3	2			2		2			2	3		2
CO4	3	2						2						
CO5	3	3		2		2		2				2		2

23EEPSPEXX	SOLID STATE DRIVES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To develop models for dc and ac motors.
- To learn the operation of phase control and chopper controlled dc drives.
- To understand the operation of induction motor drives
- To gather knowledge on the theory of synchronous motor drives.
- To brief about the working principle of Special Electrical Drives

INTRODUCTION

Introduction - Fundamentals of electric drives - Comparison between conventional and solid state drives - Open loop and closed loop speed control -. Classification, characteristics and advantages of electric drives - Selection of power rating for drive motor based on thermal limits. Transfer function and State space models of series and separately excited DC motor - Motor transfer function - Speed and current loops-load torque disturbance - AC Machines - Dynamic modeling - Linear transformations - equations in stator, rotor and synchronously rotating reference frames - Flux linkage equations - Dynamic state space model - Modeling of Synchronous motor.

DC DRIVES

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 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

1. Gopal K. Dubey,"Fundamentals of Electrical Drives‖", CRC Press, Second Edition, 2002.
2. K.Venkataratnam, "Special Electrical Machines", Universities press, 2009.
3. Austin Hughes and Bill Drury, "Electric Motors and Drives": Fundamentals, types and Applications‖, Elsevier Ltd, Fourth Edition, 2013.
4. Vedam Subramaniam, "Electric Drives-Concepts and applications", Tata McGraw Hill Publishing Company Ltd, 2002.

COURSE OUTCOMES

At the end of the course work the students will be able to

1. Model and analyze electrical motor drives and their sub systems (converters, rotating machines and loads)
2. Understand the working of dc drives
3. Arrive at theory of induction motor drives
4. Enable the operation of synchronous motor drives
5. Gather an insight into the special machines drives.

Mapping with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	1		2			1			1	1	1	
CO2	2	2	1		2			1			1	1	1	
CO3	2	2	2		2	1	1	1			2	2	2	
CO4	2	2	2		2	1	1	1			2	2	2	
CO5	2	2	2	2	1	1	1	1			2	2	2	

23EEPSPEXX	POWER SYSTEM TRANSIENTS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To understand the basics of power system transients
- To gain knowledge about the digital computation for power system protection
- To know in detail the impact of lightning in the power system
- To familiarize the concepts of Travelling waves and its impact in the transmission systems.
- To comprehend insulation co-ordination in substations

INTRODUCTION

Fundamental circuit analysis of electrical transients - Laplace Transform method of solving simple switching transients - Damping circuits - Abnormal switching transients, Three-phase circuits and transients - Computation of power system transients.

DIGITAL COMPUTATION

Principle of digital computation - Matrix method of solution - Modal analysis - Z transform-Computation using EMTP - Lightning, switching and temporary over voltages, Lightning - Physical phenomena of lightning.

IMPACT OF LIGHTNING

Interaction between lighting and power system-Influence of tower footing resistance and Earth Resistance-Switching: Short line or kilometric fault - Energizing transients - Closing and Re-closing of lines-line dropping, load rejection - Over voltages induced by faults.

SWITCHING HVDC LINE

Travelling waves on transmission line - Circuits with distributed Parameters Wave Equation-Reflection, Refraction, Behavior of Travelling waves at the line terminations - Lattice Diagrams - Attenuation and Distortion - Multi-Conductor system-and Velocity wave.

INSULATION CO-ORDINATION

Principle of insulation co-ordination in Air Insulated substation (AIS) and Gas Insulated Substation (GIS) Co- ordination between insulation and protection level- Statistical approach - Protective devices - Protection of system against over voltages - Lightning arresters - Substation earthing.

REFERENCES

1. Allan Greenwood, "Electrical Transients in Power System", Wiley & Sons Inc. New York, 1991
2. C.S.Indulkar, DP Kothari, "Power System Transients‖ - A Statistical approach", Prentice Hall, 1996.
3. Akihiro Ametani, Naoto Nagaoka, Yoshihiro Baba, Teruo Ohno, "Power System Transients: Theory and Applications", CRC Press, 2013.
4. Lou van der Sluis, "Transients in Power Systems", John Wiley & Sons, 2001.
5. Arrillaga. J and Watson.N., "Power Systems: Electromagnetic Transients simulation, The Institution of Engineering and Technology", London, 2007.
6. Bewley, L..V., "Travelling Waves on Transmission System", Power Publications Inc., 1993.

COURSE OUTCOMES

At the end of the course work the students will be able to

1. Acquire the basic knowledge about occurrence of various types of power system transients and their mathematical formulation
2. Compute various parameter for the power system design due to lighting impacts.
3. Coordinate the insulation of various equipment in power system lighting
4. Model the power system for transient analysis considering switching HVDC line
5. Understand the need for Insulation co-ordination

Mapping with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2										2		
CO2	3	2	3	2								3		2
CO3	3		2	2								2		
CO4	3		2									2		
CO5	3		2	2								3		2

23EEPSPEXX	INSULATION TECHNOLOGY AND HIGH VOLTAGE ENGINEERING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To understand the fundamental concepts in High Voltage Engineering.
- To acquire knowledge on Electrostatic Fields and the control methodologies involved in the control of Field Stress
- To study about the various types of High Voltage Testing methods and equipments.
- To learn in detail about SF_6 Circuit Breakers.
- To comprehend in detail about High Voltage Transients in Power systems

INTRODUCTION

Fundamentals of high voltage engineering - Voltage stresses - Testing voltages - Testing with power frequency voltages - Testing with lightning impulse voltages - Testing with switching impulse voltages - Testing with d.c. Voltages - Over voltages - Simulated lightning surges for testing - Switching surge test voltage characteristic.

ELECTROSTATIC FIELDS AND FIELD STRESS CONTROL

Electrical field distribution and break down strength of insulating materials - Simple configurations of fields - Stress control by floating screens - Experimental field analysis techniques - Finite element numerical method - Charge simulation method.

HIGH VOLTAGE TESTING

High voltage testing of electrical equipment - Testing of overhead line insulators, cables, bushings, power capacitors - Power transformers, circuit breakers - Various kinds of test voltages

CIRCUIT BREAKERS

SF6 gas insulated power apparatus - SF6 Circuit breakers - SF6 metal enclosed substations - General design considerations - Maintenance of SF6 metal enclosed substations - SF6 insulated current transformers - Design considerations - SF6 gas insulated bushings - SF6 gas insulated cables - Testing procedure for testing SF6 insulated power apparatus.

TRANSIENTS

High Voltage transients in power system - Traveling waves on transmission lines - Capacitance switching - Lightning phenomenon - Line design based on lightning - Over voltage protection - Graved wires - Surge protection of power apparatus.

TEXT BOOK

1. Kuffel. E and Zaengl. W.S, 'High Voltage Engineering Fundamentals', Pergamon Press, Oxford 1984 Publisher : Robert Maxwell, MC
2. Dieter Kind, 'An Introduction to High Voltage Experimental Techniques', Wiley Eastern Ltd., New Delhi, 2013.

REFERENCE BOOKS

1. Raju, Gorur G, 'Dielectrics in Electric Fields', 2nd Edn, CRC Press, 2016
2. Denno, Khalil, 'High Voltage Engineering in Power Systems', CRC Press, 2018
3. Dekker.A.J, 'Electrical Engineering Materials', Prentice Hall of India, NewDelhi.1987
4. Gallagher T.J. and Peermain.A. "High Voltage Measurement, Testing and Design" Wiley–Blackwell, New York, 1983
5. Wadhwa. C.L, 'High voltage Engineering', New Age International Pvt Ltd., 3rd Edn, New Delhi, 2015.
6. Naidu M.S., Maller V.N, 'SF6 and vacuum Insulation for High Voltage Applications', Khanna Publishers, New Delhi, 1998
7. Abu Hanieh Saleh, 'Electric Field Optimization in Sf6 Circuit Breakers', LAP Lambert Academic Publishing, Republic of Moldova, 2015

COURSE OUTCOMES

At the end of the course work, The students will be able to

1. Understand the fundamental concepts in High Voltage Engineering.
2. Gain knowledge about the Electrostatic Fields and the control methodologies involved in the control of Field Stress
3. Know the various types of High Voltage Testing methods and equipments.
4. Comprehend the contrition and operation of SF_6 Circuit Breakers.
5. Familiarize High Voltage Transients and its impact in Power systems

Mapping with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2										2		
CO2	3	3										3		
CO3	3	3										3		
CO4	3	3										3		
CO5	3	3										3		

SEMESTER III

23EEPSPEXX	FACTS AND CUSTOM POWER DEVICES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To learn the active and reactive power flow control in power system
- To understand the need for static compensators
- To gain knowledge about the static series compensation
- To familiarize the construction and operation of Unified Power Flow Controller
- To comprehend the construction and operation of Interline Power Flow Controller

REACTIVE POWER FLOW CONTROL

Control of dynamic power unbalances in Power System - Power flow control-Constraints of maximum transmission line loading - Benefits of FACTS Transmission line compensation - Uncompensated line - Shunt compensation, Series compensation Phase angle control - Reactive power compensation Shunt and Series compensation principles - Reactive compensation at transmission and distributionlevel

VAR COMPENSATOR

Static shunt compensators: SVC and- STATCOM - Operation and control of TSC, TCR and STATCOM -Compensator control-Comparison between SVC and STATCOM

STATIC SERIES COMPENSATION

TSSC, SSSC - Static voltage and phase angle regulators-TCVR and TCPAR Operation and Control-Applications, Static series compensation - GCSC, TSSC, TCSC and Static synchronous series compensators and their Control- SSR and its damping

UNIFIED POWER FLOW CONTROLLER

Circuit Arrangement, Operation-and control of UPFC - Basic Principle of P and Q control - Independent real and reactive power flow control - Applications.

INTERLINE POWER FLOW CONTROLLER

Modeling and analysis of FACTS - Controllers - Simulation of FACTS controllers - Power quality problems in distribution systems - Harmonics, loads that create harmonics-modeling, harmonic - Propagation, series and parallel resonances mitigation of harmonics-passive filters, active filtering - Shunt , series and hybrid and their control - Voltage swells, sags, flicker, unbalance and mitigation of these problems by power line conditioners - IEEE standards on power quality.

REFERENCES

1. K R Padiyar, "FACTS Controllers in Power Transmission and Distribution", New Age International Publishers, 2007
2. X P Zhang, C Rehtanz, B Pal, "Flexible AC Transmission Systems- Modelling and Control", Springer Verlag, Berlin, 2006
3. N.G. Hingorani, L. Gyugyi, "Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems", IEEE Press Book, Standard Publishers and Distributors, Delhi, 2001.
4. K.S.Sureshkumar, S. Ashok , "FACTS Controllers & Applications", E-book edition, Nalanda Digital Library, NIT, Calicut,2003
5. G T Heydt, "Power Quality", McGraw-Hill Professional, 2007
6. T J E Miller, "Static Reactive Power Compensation", John Wiley and Sons, New York, 1982.

COURSE OUTCOMES

At the end of the course work, the students will be able to

1. Acquire knowledge about the fundamental principles of Passive and Active Reactive Power Compensation Schemes at Transmission and Distribution level in Power Systems.
2. Learn various Static VAR Compensation Schemes like Thyristor/GTO Controlled Reactive Power Systems; PWM Inverter based Reactive Power Systems.
3. Develop analytical modelling skills needed for modelling and analysis of such Static VAR Systems.
4. Equip with basic procedure of FACTS controller Design.
5. Gain knowledge on IEEE standards on power quality.

Mapping with Program Outcomes														
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**		**3**						**2**			**3**		
CO2	**3**	**2**		**2**								**2**		
CO3	**3**	**3**	**2**	**2**								**3**		
CO4	**3**	**2**		**2**					**1**			**3**		
CO5	**1**	**2**		**2**								**1**		

23EEPSPEXX	POWER QUALITY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To understand the different power quality issues
- To know in detail about the power system harmonics
- To gain knowledge about the components used in power system network and its modeling
- To comprehend in detail about power factor and its improvements
- To familiarize the various STATIC VAR Compensators

INTRODUCTION

Voltage quality - Overview of power quality phenomena classification of power quality issues-Power quality measures and standards-THD-TIF-DIN-C- message weights - Flicker factor transient phenomena - Occurrence of power quality problems - Power acceptability curves-IEEE guides, standards and recommended practices.

HARMONICS

Individual and total harmonic distortion RMS value of a harmonic waveform - Triplex harmonics -Important harmonic introducing devices – SMPS - Three phase power converters - Arcing devices saturable devices - Harmonic distortion of fluorescent lamps - Effect of power system harmonics on power system equipment and loads.

MODELING OF NETWORKS AND COMPONENTS

Transmission and distribution systems - Shunt capacitors -Transformers - Electric machines - Ground systems - Loads under non-sinusoidal conditions - Impact ondrive

POWER FACTOR IMPROVEMENT

Passive Compensation Passive Filtering, Harmonic Resonance - Impedance Scan Analysis - Active Power Factor Corrected Single Phase Front End, Control Methods for Single Phase APFC Three Phase APFC and Control Techniques, PFC Based on Bilateral Single Phase and Three Phase Converter

STATIC VAR COMPENSATORS

SVC and STATCOM Active Harmonic Filtering - Shunt Injection - Filter for single phase, three-phase three-Wire and three - Phase four- Wire systems d-q domain control of three phase shunt active filters uninterruptible power supplies constant voltage - Transformers series active power filtering techniques for harmonic cancellation and isolation - Dynamic Voltage Restorers for sag, swellandflickerproblems. Groundingandwiringintroduction NECgrounding requirements –

Reasons for grounding typical grounding and wiring problems solutions to grounding and wiring problems

REFERENCES

1. G.T. Heydt, “Electric power quality”, McGraw-Hill Professional, 2007
2. Math H. Bollen, “Understanding Power Quality Problems”, IEEE Press, 2000
3. J. Arrillaga, “Power System Quality Assessment”, John Wiley, 2000
4. J. Arrillaga, B.C. Smith, N.R. Watson &A. R.Wood, “Power System Harmonic Analysis”, Wiley, 1997.

COURSE OUTCOMES

At the end of the course work the students will be able to

1. Acquire knowledge about the harmonics, harmonic introducing devices and effect of harmonics on system equipment andloads
2. Develop analytical modeling skills needed for modeling and analysis of harmonics in networks and components
3. Introduce the active power factor correction based on static VAR compensators and its control techniques
4. Implement the series and shunt active power filtering techniques for harmonics.
5. Find solutions to grounding and wiring problems

Mapping with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2			1		1						2		1
CO2	3			1		1						2		1
CO3	3			1		1						2		1
CO4	2			1		1						2		1
CO5	2			2								2		1

23EEPSPEXX	INDUSTRIAL LOAD MODELING AND CONTROL	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To understand the basic concepts of demand side management in the electrical energy scenario
- To familiarize the various cost imposed with electricity pricing models
- To understand the impacts and need for reactive power management in industries.
- To study about the various types of load models and its impact
- To gain knowledge about the captive power generation units.

ELECTRIC ENERGY SCENARIO

Demand Side Management - Industrial Load Management - Load Curves - Load Shaping Objectives - Methodologies - Barriers - Classification of Industrial Loads - Continuous and Batch processes - Load Modeling

ELECTRICITY PRICING

Dynamic and spot pricing - Models - Direct load control - Interruptible load control - Bottom up approach - Scheduling - Formulation of load - Models Optimization and control algorithms - Case studies

REACTIVE POWER MANAGEMENT

In industries - Controls - Power quality impacts - Application of filters - Energy saving in industries - Cooling and heating loads

LOAD PROFILING-MODELING

Cool storage -Types - Control strategies - Optimal operation - Problem formulation - Case studies

CAPTIVE POWER UNITS

Operating and control strategies-Power Pooling- Operation models - Energy banking-Industrial Cogeneration - Selection of Schemes - Optimal Operating Strategies - Peak load saving - Constraints Problem formulation - Case study - Integrated Load management for Industries.

REFERENCES

1. C.O. Bjork, “Industrial Load Management - Theory, Practice and Simulations”, Elsevier, Netherlands,1989
2. C.W. Gellings and S.N. Talukdar, “Load management concepts”. IEEE Press, New York, 1986.

3. Y. Manichaikul and F.C. Schweppe , "Physically based Industrial load", IEEE Trans. on PAS, April,1981, pp.1439-1445
4. H. G. Stoll, "Least cost Electricity Utility Planning", Wiley Inter Science Publication, USA, 1989.
5. I.J.Nagarath and D.P.Kothari, "Power System Engineering", Tata McGraw Hill Publishers, New Delhi, 2007
6. IEEE Bronze Book, "Recommended Practice for Energy Conservation and cost effective planning in Industrial facilities", IEEE Inc, USA, 1984

COURSE OUTCOMES

At the end of the course work the students will be able to

1. Learn the basic concepts of demand side management in the electrical energy scenario
2. Study the various cost imposed with electricity pricing models
3. Familiarize understand the impacts and need for reactive power management in industries.
4. Design various types of load models and analyse itsimpact
5. Gain knowledge about the captive power generationunits.

Mapping with Program Outcomes														
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**											**3**		
CO2	**3**											**2**		
CO3	**3**			**2**							**2**	**2**		
CO4	**3**											**2**		
CO5	**3**			**2**							**2**	**3**		

23EEPSPEXX	BIG DATA ANALYTICS IN ELECTRIC POWER SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To impart knowledge about the application of Big Data in a Power Systems
- To know about the Big Data Optimization in Electric Power Systems
- To introduce the concept of Data-Mining Methods for Electricity Theft Detection
- To understand the security methods for Critical Infrastructure Communications and Big Data in Smart Grid Communications
- To gain knowledge on Unit Commitment Control of Smart Grids

BIG DATA APPLICATION AND ANALYTICS IN A POWER SYSTEM

Introduction - General Applications of Big Data - Social Networking - Handling Big Data - Algorithms for Processing Big Data- Machine Learning and Deep Learning Generalities- Machine Learning - Support Vector Machine (SVM) - Decision-Tree Classifier - Deep Learning - Deep Learning Models - Challenges and Suggested Solutions for Using Deep Learning in Big Data Analytics - Application of Big Data in Power Systems - Big Data in Smart Grid Networks - Phasor Measurement Units (PMU - Renewable Energy - CIM as Information Standard for Big Data Analytics - Big Data Problem in Power System Modelling - Security - Constrained Unit Commitment (SCUC) - Decomposition Methods to Handle Big Data - Firm Transmission Right (FTR) Problems - Time -Constrained Economic Dispatch

BIG DATA OPTIMIZATION IN ELECTRIC POWER SYSTEMS

Introduction - Scientometric Analysis of Big Data - Big Data and Power Systems - Big Data Optimization - Application of Big Data in Power System Studies- Optimization Techniques Used in the Big Data Analysis - Computational Method for Large-scale Unconstrained Optimization - Numerical Approach for Nonsmooth Large-scale Optimization - Big Data in Logistics Optimization - Big Data Analytics Based on Convex and Nonconvex Optimization - Metaheuristic Algorithms for Big Data Optimization

DATA-MINING METHODS FOR ELECTRICITY THEFT DETECTION

Introduction - Transmission and Distribution System Losses - Electricity Theft Methods- Fraud - Bypassing Existing Meetings- Meter Tampering - Billing Issues - Outright Theft - Electricity Theft and Data Collection - Data Mining and Electricity Theft - Prediction - Classification and Clustering - Detection - Issues and Directions in Electricity Theft-Related Data-Mining Research.

SECURITY METHODS FOR CRITICAL INFRASTRUCTURE COMMUNICATIONS

Introduction - Effects of Successful Communication System Threats - General Communication

System Operations - Industrial Control Networks and Operations - Industrial Control Network Operations and Components - Commercial Technology Inroads into Industrial Control Networks - High-Level Communication System Threats - Actor-Based Threats: Insider versus Outsider - Device Property and Existential-Related Issues - Host-Based Threats - Physical versus Electronic Threats and Mitigation - Supply-Chain - Related Threats and Mitigation - Information Damage-Related Threats - Stack-Based Exploitations - Cyber Threats and Security - Component-Specific-Related Threats and Mitigation - Software and Communication Threats and Mitigation - Physical-Layer Threats and Security Measures -Biometric-Like Security with Physical-Layer Security Measures

UNIT COMMITMENT CONTROL OF SMART GRIDS

Introduction - Grid Modernization - Grid Interconnection with the Internet of Things - Data Traffic Pattern in a Smart Grid Environment - Phasor Measurement Unites Applied to Distribution Systems - Advanced Metering Infrastructure (AMI) - Massive Flow of Information in a Smart Scenario - Volume of Generated Data in a Smart Distribution System:- Generated Data by PMUs, Metering Infrastructure - Renewable Energy Resources - Wind Power Generation - Solar Power Generation - Solar Panel Capacity and Efficiency - Solar Panel Power Generation Density -The Unit Commitment Problem - Multi-agent Architecture - Smart Grid Using Multi-Agent Model - Agent's Profile - Decision - Making Method - Storing and Selling Extra Power Procedure.

TEXT BOOKS

1. Ahmed F. Zobaa and Trevor J. Bihl, "Big Data Analytics in Future Power Systems", CRC Press, Taylor & Francis Group, Boca Raton, 2019
2. Ali Tajer, Samir M. Perlaza, H. Vincent Poor, "Advanced Data Analytics for Power Systems", Cambridge University Press, Cambridge, 2021

REFERENCE BOOKS

1. Venkat Ankam , "Big Data Analytics, CBS Publishers and Distributors Pvt Ltd", New Delhi, 2016
2. Alpaydin,E., "Introduction to Machine Learning. Cambridge", MA, MIT Press, 2014.
3. Gaurav Aroraa, Chitra Lele, Munish Jindal, "Data Analytics: Principles, Tools, and Practices: A Complete Guide for Advanced Data Analytics Using the Latest Trends, Tools, and Technologies", BPB Publications, New Delhi, 2022
4. Robert C. Qiu and Paul Antonik, "Smart Grid using Big Data Analytics A Random Matrix Theory Approach", John Wiley & Sons Ltd, New Jersey, 2017
5. LuR, "Privacy-Enhancing Aggregation Techniques for Smart Grid Communications", Springer: Berlin/Heidelberg, Germany, 2016
6. C. L. Stimmel, "Big Data Analytics Strategies for the Smart Grid", CRC press, Boca Raton, 2014.

7. Sudip Misra, Samaresh Bera, "Smart Grid Technology: A Cloud Computing and Data Management Approach", Cambridge University Press, Cambridge, 2018.

COURSE OUTCOMES

At the end of the course work the students will be able to

1. Know the basic concepts of Big Data in a Power Systems
2. Gain knowledge about the Big Data Optimization in Electric Power Systems
3. Implement various methodologies for Data-Mining Methods for Electricity Theft Detection
4. Understand the security methods for Critical Infrastructure Communications and Big Data in Smart Grid Communications
5. Acquire knowledge about Unit Commitment Control of Smart Grids

Mapping with Program Outcomes														
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**	**2**		**2**					**2**			**3**		
CO2	**3**	**2**		**2**					**2**			**3**		
CO3	**3**	**2**		**2**					**2**			**3**		
CO4	**3**	**2**		**2**					**2**			**3**		
CO5	**3**	**2**		**2**					**2**			**3**		

23EEPSPEXX	POWER SYSTEM SIGNAL PROCESSING FOR SMART GRIDS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To introduce the basic concepts of power system signal processing
- To impart knowledge on multirate systems and sampling
- To know about the estimation of various electrical parameters
- To understand time-frequency signal decomposition
- To gain knowledge about signal detection for electric power systems

BASIC POWER SYSTEMS SIGNAL PROCESSING

Introduction - Linear and Time-Invariant Systems - Frequency Response of LTI System - Linear Phase FIR Filter - Basic Digital System and Power System Applications - Moving Average Systems: Application -RMS Estimation - Trapezoidal Integration and Bilinear Transform-Differentiators Filters: Application - Simple Differentiator - Parametric Filters in Power System Applications - Filter Specification - First-Order Low-Pass Filter - First-Order High-Pass Filter - Band stop IIR Digital Filter (The Notch Filter) - Total Harmonic Distortion in Time Domain (THD) - Signal Decomposition using a Notch Filter - Parametric Notch FIR Filters - Sine and Cosine FIR Filters - Smart-Grid Context and Conclusions

MULTIRATE SYSTEMS AND SAMPLING ALTERATIONS

Introduction - Basic Blocks for Sampling Rate Alteration - Frequency Domain Interpretation - Up-Sampling in Frequency Domain - Down-Sampling in Frequency Domain - The Interpolator - The Input - Output Relation for the Interpolator - Multirate System as a Time-Varying System and Nobles Identities - The Decimator - Introduction - The Input–Output Relation for the Decimator - Fractional Sampling Rate Alteration – Resampling - Real-Time Sampling Rate Alteration - Spline Interpolation - Cubic B-Spline Interpolation. Supervision and Control - Protection - Power Quality - Mathematical Model for Noise - Sampling and the Anti-Aliasing Filtering - Sampling Rate for Power System Application - Smart-Grid Context

ESTIMATION OF ELECTRICAL PARAMETERS

Introduction - Estimation Theory - Least-Squares Estimator (LSE) - Linear Least-Squares - Frequency Estimation - Frequency Estimation Based on Zero Crossing(IEC61000-4-30) - Short-Term Frequency Estimator Based on Zero Crossing - Frequency Estimation Based on Phasor Rotation -Varying the DFT Window Size - Frequency Estimation Based on LSE 2017.4.6 IIR Notch Filter - Small Coefficient and/or Small Arithmetic Errors - Phasor Estimation - Introduction - The PLL Structure - Kalman Filter Estimation - Example of Phasor Estimation using Kalman Filter - Phasor Estimation in Presence of DC Component - Mathematical Model for the Signal in

Presence of DC Decaying - Mimic Method - Least-Squares Estimator - Improved DTFT Estimation Method.

TIME-FREQUENCY SIGNAL DECOMPOSITION

Introduction - Short-Time Fourier Transform - Filter Banks Interpretation - Choosing the Window: Uncertainty Principle - The Time-Frequency Grid - Sliding Window DFT - Sliding Window DFT: Modified Structure - Power System Application - Filter Banks - Two-Channel Quadrature-Mirror Filter Bank - An Alias-Free Realization - A PR Condition - Finding the Filters from P(z) - General Filter Banks - Harmonic Decomposition Using PR Filter Banks - The Sampling Frequency - Extracting Even Harmonics - The Synthesis Filter Banks - Wavelet - Continuous Wavelet Transform - The Inverse Continuous Wavelet Transform - Discrete Wavelet Transform (DWT) - The Inverse Discrete Wavelet Transform - Discrete-Time Wavelet Transform - Design Issues in Wavelet Transform - Power System Application of Wavelet Transform - Real-Time Wavelet Implementation

DETECTION

Introduction - Signal Detection for Electric Power Systems - Detection Theory Basics - Detection on the Bayesian Framework - Newman-Pearson Criterion - Receiving Operating Characteristics - Deterministic Signal Detection in White Gaussian Noise - Deterministic Signals with Unknown Parameters - Detection of Disturbances in Power Systems - The Power System Signal - Optimal Detection - Feature Extraction - Commonly Used Detection Algorithms - Transmission Lines Protection - Detection Algorithms Based on Estimation - Saturation Detection in Current Transformers - Smart-Grid Context.

TEXT BOOKS

1. Paulo Fernando Ribeiro, Carlos Augusto Duque, Paulo M_arcio da Silveira, Augusto Santiago Cerqueira, “Power Systems Signal Processing For Smart Grids”, John Wiley & Sons Ltd, West Sussex, UK, 2014

REFERENCE BOOKS

1. Oppenheim, A.V, Willsky, A.S and Nawab, H, “Signals and Systems”, Prentice Hall, 1997
2. Oppenheim, A.V. and Schafer, R.W, “Discrete-Time Signal Processing”, 3rd edn, Prentice Hall, 2009
3. Mitra, S.K, “Digital Signal Processing: A Computer-Based Approach”, 4th Edn, McGraw-Hill, 2005.
4. Lathi, B.P, “Linear Systems and Signals”, Oxford University Press, Oxford, 2004.
5. Natarajan R, “Power System Capacitors”, CRC Press, Boca Raton, 2005.

6. Reimert, D, “Protective Relaying for Power Generation Systems”, CRC Press, Taylor & Francis Group, 2006
7. Blackburn, J.L, “Protective Relaying: Principles and Application”, 3rd edn, CRC Press., 2007.
8. Acha, E. and Madrigal, M, “Power Systems Harmonics: Computer Modelling and Analysis”, Wiley& Sons, 2001
9. Ibrahin, M.A, “Disturbance Analysis for Power Systems”, Wiley & Sons, 2012.
10. Lyons, R.G, “Understanding Digital Signal Processing”, Prentice Hall, 2011.
11. Proakis, J.G. and Manolakis, D.G., “Digital Signal Processing: Principles, Algorithms and Applications”, Prentice Hall, 2007.
12. Baggini A, “Handbook of Power Quality”, John Wiley & Sons, Chichester, 2008.
13. Antoniou A, “Digital Filters, Analysis, Design and Applications”, McGraw Hill, 1993

COURSE OUTCOMES

At the end of the course work the students will be able to

1. Known the basic concepts of power system signal processing
2. Gain knowledge about the multirate systems and sampling
3. Implement various methodologies for the estimation of various electrical parameters
4. Understand time-frequency signal decomposition
5. Acquire knowledge about the signal detection for electric power systems

Mapping with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2		2								3		2
CO2	3	2		2								3		2
CO3	3	2	2	2								3		2
CO4	3	2		2								3		2
CO5	3	2		2								3		2

23EEPSPEXX	POWER SYSTEM RELIABILITY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To impart the basic knowledge about Reliability in Power System Engineering
- To know in detail about Transmission System Reliability
- To study about Bulk Power System Reliability
- To gain knowledge about the Generation Capacity reliability in Interconnected Power System
- To familiarize with the Distribution System Reliability

BASIC RELIABILITY CONCEPTS

General reliability function - The exponential distribution meantime to failure - Series and parallel systems - Markov processes - Continuous markov processes - Recursive techniques.

TRANSMISSION SYSTEM RELIABILITY

Average interruption rate method - Frequency and duration method - Stormy and normal weather effects - Markov process approach - System studies.

BULK POWER SYSTEM RELIABILITY

Service quality criterion - Conditional probability approach - Single system application - Two plant, single load system - Two plant, two load system - Networked system approach.

INTERCONNECTED SYSTEM GENERATING CAPACITY RELIABILITY

Probability array for two systems - Loss of load approach - Load forecast uncertainty - Interconnection benefits.

DISTRIBUTION SYSTEM RELIABILITY

Markov model - Distribution system reliability performance

TEXT BOOK

1. Roy Billington, ‘Power System Reliability Evaluation’, Gordon and Breach Science Publishers, New York, 1970.
2. Balbi Dhillon .S, ‘Power System Reliability, Safety and Management, Ann Arbor Science, 1984.

REFERENCE BOOKS

1. Sandler, Gerald H, ‘System Reliability Engineering’, Literary Licensing, LLC, 2012

2. G.F. Kovalev, L.M. Lebedeva, ‘Reliability of Power Systems’, Springer International Publishing, 2019
3. Roy Billington and Ronald Allan.N, ‘Reliability Evaluation of Engineering Systems, Concepts and Techniques’, Pitman Advanced Publishing Program, 1984.
4. Endrenyi .J, ‘Reliability Modelling in Electric Power Systems’, Wiley–Blackwell, 1978.
5. Turan Gonen, ‘Electric Power Distribution System Engineering’, CRC Press, Boca Raton, 3rd Edn, 2014

COURSE OUTCOMES

At the end of the course work, Students will be able to

1. Understand the fundamental aspects of Power System Reliability
2. Gather details relating to Transmission System Reliability
3. Arrive at solutions for Bulk Power System Reliability
4. Enable Generation Capacity reliability in Interconnected Power System
5. Articulate on Distribution System Reliability

Mapping with Program Outcomes													
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**	**2**										**2**		
CO2	**3**	**3**										**3**		
CO3	**3**	**2**										**3**		
CO4	**3**	**3**										**3**		
CO5	**3**	**3**										**3**		

23EEPSPEXX	POWER SYSTEM INSTRUMENTATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To comprehend the basic concept of measurements an SCADA Systems
- To impart knowledge on the various types of Power Plant Instruments.
- To know in detail about Distribution Automation
- To understand the basics of Substation automation
- To gain knowledge about the various Instruments / Techniques for Energy Management in Power Systems

MEASUREMENTS AND SCADA SYSTEMS

Measurement and error analysis - Object and philosophy of power system instrumentation to measure large currents, high voltages, Torque and Speed - Standard specifications - Data acquisition systems for Power System applications - Data Transmission and Telemetry - PLC equipment - Computer control of power system - Man Machine Interface.

POWER PLANT INSTRUMENTATION

Piping and Instrumentation diagram of thermal and nuclear power plants - Fuel measurement - Gas analysis meters - Smoke measurement - Monitoring systems - Measurement and control of furnace draft - Measurement and control of combustion -Turbine monitoring and control: speed, vibration, shell temperature monitoring - Radiation detection instruments - Process sensors for nuclear power plants - Spectrum analyzers - Nuclear reactor control systems and allied instrumentation.

DISTRIBUTION AUTOMATION

Definitions - Automation switching control - Management information systems (MIS) - Remote terminal units - Communication method for data transfer - Consumer information service (CIS) - Graphical information systems (GIS) - Automatic meter reading (AMR) -Remote control load management.

SUBSTATION INSTRUMENTATION

Substation automation - Requirements - Control aspects in substations - Feeder automation - Consumer side automation - Reliability - GPIB programmable test instruments - Microprocessor / Microcontroller based GPIB controllers

ENERGY MANGEMENT TECHNIQUES AND INSTRUMENTS

Demand side management (DSM) - DSM planning - DSM Techniques -Load management as a DSM satergy - Energy conservation -Tarrif options for DSM - Energy audit - Instruments for energy audit - Energy audit for generation, distribution and utilization systems - Economic analysis.

TEXT BOOKS

1. Liptak B.G, 'Instrumentation in Process Industries', Chilton Book Co., 1973.
2. Sherry A, 'Modern Power Station Practice: Instrumentation, controls and Testing', Pergamon Press,1971.

REFERENCE BOOKS

1. Pabla. A.S "Electric power distribution "- Tata McGraw Hill; New Delhi 2004
2. Juan Manuel Gers, 'Distribution systems analysis and automation', The Institution of Engineering and Technology, 2020
3. James A. Momoh, 'Electric Power Distribution, Automation, Protection, and Control', CRC Press, 2007
4. Biswarup Das, 'Energy Engineering: Power Distribution Automation', The Institution of Engineering and Technology, 2016
5. Wayne C. Turner, Steve Doty, "Energy Management Handbook", CRC press, Taylor & Frances group, Eighth Edition, 2012.
6. W.R.Murphy, G.McKay, Energy Management, Butterworth-Heinemann, Elsevier Publishers, Oxford, 2015.

COURSE OUTCOMES

At the end of the course work, Students will be able to

1. Understand the need and usage of SCADA Systems
2. Gain knowledge about the various types of Power Plant Instruments
3. Familiarize the need for Distribution Automation
4. Acquire knowledge about the various concepts for Substation Automation
5. Acquaint about about the various Instruments / Techniques for Energy Management in Power Systems.

Mapping with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2										2		
CO2	3	3										3		
CO3	3	3										3		
CO4	3	2										2		
CO5	3	3										3		

23EEPSPEXX	HIGH VOLTAGE TESTING TECHNIQUES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To impart knowledge on basic high voltage testing methods / techniques.
- To gain knowledge about the various testing techniques for Electrical Equipment.
- To understand the concept of Impulse voltage generation.
- To educate in detail about the non-destructive testing.
- To learn various methodologies for designing high voltage laboratory.

INTRODUCTION

Necessity for high voltage testing - Classification of testing methods - Self - Restoration and Non-self-restoration systems - Standards and specifications, measurement techniques.

TESTING TECHNIQUES FOR ELECTRICAL EQUIPMENT

Testing of power transformers - Voltage transformers - Current transformers - Bushings - Insulators - Surge-diverters - Cables - Circuit breakers and isolators - Testing methodology - Recording of oscillograms - Interpretation of test results

GENERATION OF IMPULSE VOLTAGES

Impulse voltage generator circuit - Analysis of various impulse voltage generator circuits - Multistage impulse generator circuits, Marx generator - Switching impulse generator circuit - Impulse current generator circuits.

NON-DESTRUCTIVE TESTING

Measurement of tan delta and capacitance of solid and liquid dielectrics - Insulation resistance measurement - Partial discharges - Location and measurement of discharges in electrical equipment - RIV measurements on line hardware, Methodology and interpretation.

DESIGN OF HIGH VOLTAGE LABORATORY

General layout of high voltage laboratory - Design aspects from civil and electrical engineering points of view - Choice of equipment - Earthing and shielding - Power supply and safety circuits.- Fault diagnostic techniques - Statistical interpretation of test data-50 percent disruptive discharge voltage-up and down method - Transfer function approach - Pattern recognition approach - Neural networks approach.

TEXT BOOKS

1. Naidu M S and Kamaraju V., 'High Voltage Engineering', McGraw Hill Education; 5th Edn, 2017.
2. Gallagher T J and Pearmain A.," High voltage measurement, testing and design", John Wiley & Sons, New York, 1983.

REFERENCE BOOKS

1. Dieter Kind, 'High voltage experimental technique', Vieweg+Teubner Verlag Publishers, Wiesbaden, 2013.
2. E.Kuffel, W.S. Zaengl, J.Kuffel, 'High Voltage Engineering Fundamentals', Newnes, 2nd Edn, Oxford, 2000.
3. Denno, Khalil, 'High Voltage Engineering in Power Systems', CRC Press, 2018
4. Hugh M. Ryan, 'High Voltage Engineering and Testing', The Institution of Engineering and Technology, 2013
5. Wolfgang Hauschild, Eberhard Lemke, 'High-Voltage Test and Measuring Techniques', Springer, 2014
6. Klaus Schon, 'High Voltage Measurement Techniques: Fundamentals, Measuring Instruments, and Measuring Methods', Springer International Publishing, 2019

COURSE OUTCOMES

At the end of the course work the students will be able to

1. Learn the basics about the high voltage testing methods / techniques
2. Gain an enhanced knowledge about the various testing techniques for Electrical Equipment.
3. Attain knowledge about time varying and time invariant feedback concepts.
4. Acquire conceptual knowledge about the concept of Impulse voltage generation.
5. Familiarize with the methodologies for designing high voltage laboratory

Mapping with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2										3		
CO2	3	2										3		
CO3	3	3										3		
CO4	3	2										3		
CO5	3	3										3		

OPEN ELECTIVE COURCES

23YYZZOEXX	ENERGY MANAGEMENT AND AUDIT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVE

- To familiarize the energy management in Electrical Drives
- To learn the energy management schemes in Electric Heating and Lighting
- To understand the basics of Distribution Automation
- To learn in detail about the Demand Side Management
- To gain in depth knowledge about Energy Audit.

ENERGY MANAGEMENT IN ELECTRIC DRIVE

Motors and Adjustable speed drives - High efficiency motors - Rewinding electric motors - Motor drives and controls - Other factors in motor system efficiency - Utility rebates for motor and drives.

ENERGY MANAGEMENT IN ELECTRIC HEATING AND LIGHTING

Industrial heating - Resistance heating, induction heating, arc heating, dielectric and micro wave heating - Radiant heating -Cost of electrical energy - Lighting - Lamp life time - Efficient lighting - Motive power and power factor improvement - Capacitor rating - Siting of capacitors - Effects of power factor improvement - Temperature measurement - Optimum start control - Efficient use of electrical energy in air conditioning.

DISTRIBUTION AUTOMATION

Introduction - Need Based Energy Management (NBEM) - Advantages - Conversional distribution network - Automated system - Distribution Automation System (DAS) - Communication interface - PLCC - Different data communication systems - Distribution SCADA - Distribution automation - Load management in automated distribution system - RTU - Substation automation - Feeder automation - Consumer side automation - Energy audit concept - Reduced line loss - Power quality - Differed capital expenses - Energy cost reduction - Optimal energy use - Improved reliability.

DEMAND SIDE MANAGEMENT

Introduction -Scope of demand side management (DSM) - Evolution of DSM concepts - DSM planning and implementation - Load management as DSM strategy - Application of load control - End use of energy conversion - Tariff options for DSM - Customer acceptance - Implementation issues - Implementation strategies - DSM environment - International experience with DSM.

ENERGY AUDIT

Basic principles of energy audit - Definition of energy auditing - Objectives - Energy flow diagram - Strategy of energy audit - Comparison with standards - Energy management team - considerations in implementing energy with conservation programmes - Periodic progress review - Instruments for energy audit - Energy audit of electrical system - Energy audit of heating, ventilation and air conditioning systems - Energy audit of compressed air systems -Energy audit of buildings - Energy audit of steam generation, distribution and utilization systems - Economic analysis - Energy audit case studies.

REFERENCE BOOKS

1. Rakosh Das Begamudre, 'Energy Conversion Systems', New Age International Publishers, New Delhi, 2015.
2. Murphy W.R, McKay G., "Energy Management", Butterworth-Heinemann (Elsevier) Publications, London, 2015.
3. Trivedi P.R., Julka B.R., "Energy Management", Common Wealth Publishers, New Delhi, 1997
4. K.V.Sharma, P.Venkataseshaiah, "Energy Management and Conservation", I.K.International Pvt., Ltd, New Delhi, 2019.
5. Albert Thumann, Terry Niehus, William J Younger, "Handbook of Energy Audits", 9th Edn, CRC Press, 2013.

COURSE OUTCOMES:

At the end of the course work, Students will be able to

1. Understand and acquire fundamental knowledge energy management in Electrical Drives
2. Acquire the energy management methodologies in Electric Heating and Lighting.
3. Understand the basics of Distribution Automation.
4. Learn in detail about the Demand Side Management
5. Gain in depth knowledge about Energy Audit.

Mapping with Program Outcomes														
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**	**3**										**3**		
CO2	**3**	**3**										**3**		
CO3	**3**	**3**										**3**		
CO4	**3**	**3**										**3**		
CO5	**3**	**3**										**3**		

23YYZZOEXX	WASTE TO ENERGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To impart the basic knowledge about Energy acquired from wastes
- To know in detail about Biomass Pyrolysis
- To study about Biomass Gasification in detail
- To gain knowledge about the Biomass combustion
- To familiarize with the properties and uses of Biogas

INTRODUCTION

To Energy from Waste: Classification of waste as fuel - Agro based, Forest residue, Industrial waste - MSW -Conversion devices -Incinerators, gasifiers, digesters.

BIOMASS PYROLYSIS

Pyrolysis - Types, slow fast - Manufacture of charcoal - Methods - Yields and application - Manufacture of pyrolytic oils and gases, yields and applications.

BIOMASS GASIFICATION

Gasifiers - Fixed bed system - Downdraft and updraft gasifiers - Fluidized bed gasifiers -Design, construction, and operation - Gasifier burner arrangement for thermal heating - Gasifier engine arrangement and electrical power - Equilibrium and kinetic consideration in gasifier operation

BIOMASS COMBUSTION

Biomass stoves - Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

BIOGAS

Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants -Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

REFERENCES

1. Desai, Ashok V., "Non-Conventional Energy", Wiley Eastern Ltd., 1990.
2. Khandelwal, K. C. and Mahdi, S. S., "Biogas Technology - A Practical Hand Book - Vol. I & II", Tata McGraw Hill Publishing Co. Ltd., 1983.

3. Challal, D. S., “Food, Feed and Fuel from Biomass”, IBH Publishing Co. Pvt. Ltd., 1991.
4. C. Y. Were Ko-Brobby and E. B. Hagan, “Biomass Conversion and Technology”, John Wiley & Sons, 1996.

COURSE OUTCOMES

At the end of the course work the students will be able to

1. Understand the basics relating to the Energy acquired from wastes
2. Learn the details about Biomass Pyrolysis
3. Articulate on the process of Biomass Gasification
4. Gather the theory about the Biomass combustion
5. Acquire a knowledge on the properties and uses of Biogas

Mapping with Program Outcomes														
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**	**2**		**3**		**1**					**2**	**2**		
CO2	**2**	**1**		**2**		**3**					**2**	**3**		
CO3	**3**					**2**					**1**	**2**		
CO4	**2**			**3**		**2**					**2**	**2**		
CO5	**2**			**2**		**2**					**1**	**2**		

23YYZZOEXX	SCADA SYSTEM AND APPLICATIONS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To understand the basics of SCADA and its functions
- To familiarize with SCADA Architecture and Communications
- To comprehend various Applications of SCADA
- To know about the various Incident response and International implications
- To get an insight into Project management for SCADA systems and records retention

INTRODUCTION TO SCADA

Data acquisition systems - Subsystems of SCADA - Functions of SCADA - Functions of SCADA - Evolution of SCADA - Monitoring and supervisory functions - SCADA applications in Utility - Automation

SCADA ARCHITECTURE AND COMMUNICATION

Different types of SCADA architectures, advantages and disadvantages of each system - Single unified standard architecture - IEC 61850 - Various industrial communication technologies - Wired and wireless methods and fiber optics - Open standard communication protocols

SCADA APPLICATIONS

Industries SCADA System Components - Schemes - Remote Terminal Unit (RTU) - Intelligent Electronic Devices (IED) - Programmable Logic Controller (PLC) -Communication Network, SCADA Server, SCADA / HMI Systems - Utility applications - Transmission and Distribution sector operations, monitoring, analysis and improvement-Industries - Oil, gas and water - Case studies, Implementation, Simulation Exercises

INTERNATIONAL IMPLICATIONS OF SECURING SCADA AND INCIDENT RESPONSE

The security environment of cyber space - The problem of unintentional cyber incidents - Critical infrastructure - Industry Response - Recommendations - Short/medium-term and long-term recommendations - Disaster recovery and business continuity of SCADA - Types of plans - Examples of SCADA systems at risk-SCADA contingency planning process - Developing the contingency planning policy statement - Identification of system resource recovery priorities - Identification of preventive controls - Difficulties with SCADA and incident response - Incident analysis- Incident prioritization - Notification - Choosing a containment strategy - Identifying the attacker - Eradication and recovery - Evidence retention.

PROJECT MANAGEMENT FOR SCADA SYSTEMS AND RECORDS RETENTION

Introduction to project management - Areas of knowledge needed - Similarities and differences with the SCADA community - Managing stakeholders and projects - Successful with SCADA implementations - SCADA implementations unique - Third-party maintenance of data - Records retention - Issues with sharing information - Sharing information has a price - Sharing data can mislead and confuse - Sharing information costs time - Sharing information has a risk

REFERENCES

1. Stuart A. Boyer, ‘SCADA-Supervisory Control and Data Acquisition’, Instrument Society of America Publications, USA, 2004
2. Gordon Clarke, Deon Reynders, ‘Practical Modern SCADA Protocols: DNP3, 60870.5 and Related Systems’, Newnes Publications, Oxford, UK,2004
3. William T. Shaw, ‘Cyber security for SCADA systems’, Penn Well Books,2021
4. Brodsky, Jacob; Radvanovsky, Robert, ‘Handbook of SCADA / control systems security’, CRC Press, 2016.
5. David Bailey, Edwin Wright, ‘Practical SCADA for industry’, Newnes, 2003
6. Michael Wiebe, ‘A guide to utility automation: AMR, SCADA, and IT systems for Electric Power’, Penn Well, 1999

COURSE OUTCOMES

At the end of the course work, Students will be able to

1. Understand the basics of SCADA and its functions
2. Gain knowledge about SCADA Architecture and Communications
3. Familiarize various Applications of SCADA
4. Acquire knowledge about the various Incident response and International implications
5. Learn and understand about Project management for SCADA systems and records retention

Mapping with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2										3		
CO2	3	3										3		
CO3	3	2										3		
CO4	3	2										3		
CO5	3	3										3		

		L	T	P	C
23YYZZOEXX	**NON CONVENTIONAL ENERGY ENGINEERING**	**3**	**0**	**0**	**3**

COURSE OBJECTIVES

- To understand basic principles of Wind Energy Conversion Systems
- To gain knowledge about the Solar Energy and methodologies for maximum energy harvesting.
- To comprehend the various Energy yielding methodologies from Bio Mass
- To impart knowledge about Geo-Thermal and Ocean Energy generation
- To familiarize the various types of Energy Sources for Energy harvesting.

WIND ENERGY

Basic principles of wind energy conversion - Site selection consideration - Types of wind mills - Basic components of wind energy conversion systems (WECS) - Types of WECS -Applications of wind energy - Safety system - Environmental aspects.

SOLAR ENERGY

Physical principles of conversion of solar radiation into heat - Flat plate collector - Collector efficiency - Concentrating collector: focusing type - Advantages of focusing collectors - Cylindrical parabolic concentrating collector - Selective absorber coatings - Central receiver tower solar power plant - Solar energy storage systems - Solar pond - Principle of solar photo voltaic cell - Solar photo voltaic power generation - MPPT (Maximum Power Point Tracking) - Solar pump - Solar hydrogen energy - Solar refrigerator.

ENERGY FROM BIO MASS

Bio gas generation principle - Types of bio-gas plants - Applications of bio-gas plants - Bio-mass as a source of energy - Energy plantation - Thermal gasification of bio mass - Energy from agricultural waste - Agro thermal power plant - Bagasse-Based cogeneration programme - Integrated waste management.

GEO-THERMAL AND OCEAN ENERGY

Nature of geo-thermal energy -Geo-thermal sources - Prime movers for geo-thermal energy conversion - advantages and disadvantages of geo-thermal energy - Application of geo-thermal energy - Principle of ocean thermal energy conversion (OTEC) - Open cycle OTEC system - Applications - Basic principle and components of tidal power plant - Site requirements - Storage - Advantages and limitations of tidal power generation - Ocean wave energy conversion devices.

OTHER ENERGY SOURCES

Basic principle and components of a fuel cell - Types of fuel cell - Advantages and disadvantages of fuel cell - Conversion energy and application of fuel cell - Basic battery theory - Batteries applied for bulk energy storage - Magneto Hydro Dynamics (MHD) - MHD generators - Working principle - Types - Characteristics - area of use - Hydrogen fuel -Hydrogen production - Storage - Transportation and utilization - Hydrogen as alternative fuel for motor vehicle - safety management.

REFERENCE BOOKS

1. Rai G.D, 'Non-Conventional Energy Sources', Khanna Publishers, New Delhi, 2000
2. Gupta B.R., 'Generation of Electrical Energy', S.Chand & Co. Ltd, New Delhi, 2001
3. Agarwal M.P, 'Future Sources of Electrical Power', S.Chand & Co. Ltd, New Delhi, 1999.
4. D.P.Kothari, K.C.Singal, Rakesh Ranjan, 'Renewable Energy Sources ans Emerging Technologies', PHI Learning Pvt. Ltd, Delhi, 2011
5. B.H.Khan, 'Non-Conventional Energy Resources', 3rd Edn, Mc Graw Hill Education (India) Pvt Ltd, New York, 2017
6. Tasneem Abbasi, S.A.Abbasi, 'Renewable Energy Sources', PHI Learning Pvt Ltd, Delhi, 2013
7. R.K.Rajput, 'Non-Conventional Energy Sources and Utilisation', S.Chand & Co. PVt Ltd, New Delhi, 2016
8. Ankur Mathur, 'Non-Conventional Sources of Energy', University Science Press, New Delhi, 2018

COURSE OUTCOMES

At the end of the course work the students will be able to

1. Comprehend the working of Wind Energy Conversion Systems.
2. Understand the various methodologies adopted for maximum energy harvesting from the Solar Energy
3. Gain knowledge about the Energy yielding methodologies from Bio Mass
4. Impart knowledge about the various Geo-Thermal and Ocean Energy generation.
5. To familiarize the concepts and solution methodologies involve with various types of Energy Sources for Energy harvesting.

Mapping with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3	2					2			3	2	
CO2	3	3	3	2					2			3	2	
CO3	3	2	2									2		
CO4	3	2	2									2		
CO5	3	2	2						2			2	2	

AUDIT COURSES

23EEPSACXX	ENGLISH FOR RESEARCH PAPER WRITING	L	T	P	C
		2	0	0	0

COURSE OBJECTIVES

- To understand that how to improve your writing skills and level of readability
- To learn about what to write in each section
- To understand the sills needed when writing a Title Ensure the good quality of paper at very first-time submission syllabus.

1. Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness
2. Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction.
3. Review of the Literature, Methods, Results, Discussion, Conclusions, the Final Check
4. Key skills that are needed when writing a Title, key skills are needed when writing an Abstract, key skills that are needed when writing an Introduction, skills needed when writing a Review of the Literature,
5. Skills that are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills that are needed when writing the conclusion.
6. Useful phrases, how to ensure paper is as good as it could possibly be the first- time submission.

REFERENCES

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books) Model Curriculum of Engineering & Technology PG Courses [Volume-I] [41]
2. Day R (2006) “How to Write and Publish a Scientific Paper”, Cambridge University Press.
3. Highman N (1998), “Handbook of Writing for the Mathematical Sciences”, SIAM Highman‘s book.
4. Adrian Wall work , “English for Writing Research Papers”, Springer New York Dordrecht Heidelberg London,2011.

23EEPSACXX	DISASTER MANAGEMENT	L	T	P	C
		2	0	0	0

COURSE OBJECTIVES

- To learn to demonstrate a critical understanding of key concepts in disaster risk reduction and human itarian response.
- To critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- To develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
- To understand the strengths and weaknesses of disaster management approaches, planning and programming.

INTRODUCTION DISASTER

Definition, factors and significance; difference between hazard and disaster; natural and manmade disasters: difference, nature, types and magnitude.

REPERCUSSIONS OF DISASTERS AND HAZARDS

Economic damage, loss of human and animal life, destruction of ecosystem natural disasters: earthquakes, volcanisms, cyclones, tsunamis, floods, droughts and famines, landslides and avalanches, man-made disaster: nuclear reactor meltdown, industrial accidents, oil slicks and spills, outbreaks of disease and epidemics, war and conflicts.

DISASTER PRONE AREAS IN INDIA

Study of seismic zones; areas prone to floods and droughts, landslides and avalanches; areas prone to cyclonic and coastal hazards with special reference to tsunami; post-disaster diseases and epidemics

DISASTER PREPAREDNESS AND MANAGEMENT

Preparedness: monitoring of phenomena triggering a disaster or hazard; evaluation of risk: application of remote sensing, data from meteorological and other agencies, media reports: governmental and community preparedness.

RISK ASSESSMENT

Disaster risk: Concept and elements, disaster risk reduction, global and national disaster risk situation. Techniques of risk assessment, global co- operation in risk assessment and warning, people‘s participation in risk assessment - Strategies for survival.

DISASTER MITIGATION MEANING

Concept and strategies of disaster mitigation, emerging trends in mitigation - Structural mitigation and Non-structural mitigation, Programs of disaster mitigation in india

REFERENCES

1. R. Nishith, Singh AK, –Disaster Management in India: Perspectives, issues and strategies‖ New Royal book Company.
2. Sahni, Pardeep Et.Al. (Eds.), Disaster Mitigation Experiences and Reflections‖, Prentice Hall of India, New Delhi.
3. Goel S. L., Disaster Administration and Management Text and Case Studies‖, Deep &Deep Publication Pvt. Ltd., New Delhi.

23EEPSACXX	SANSKRIT FOR TECHNICAL KNOWLEDGE	L	T	P	C
		2	0	0	0

COURSE OBJECTIVES

- To get a workingknowledge in illustrious Sanskrit, the scientific language in the world
- To learn Sanskrit to improve brain functioning
- To acquire Sanskrit knowledge to develop the logic in mathematics, Science & other subjects
- To get Enhanced memory power
- To explode the huge knowledge from ancient literature.

Alphabets in Sanskrit, past / present / future tense, simple sentence -Order, Introduction of roots technical information about Sanskrit literature. Technical concepts of Engineering -electrical, mechanical, architecture, mathematics

REFERENCES

1. Abhyaspustakam‖ -Dr.Vishwas, Samskrita-Bharti Publication, New Delhi
2. Teach Yourself Sanskrit Prathama Deeksha -Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. India‘s Glorious Scientific Tradition‖ Suresh Soni, Ocean books (P) Ltd., New Delhi.

COURSE OUTCOMES

At end of the course work, Students will be able to

1. Understanding basic Sanskrit language
2. Ancient Sanskrit literature about science & technology can be understood.
3. Being a global language, will help to develop logic in students.

23EEPSACXX	VALUE EDUCATION	L	T	P	C
		2	0	0	0

COURSE OBJECTIVES

- To understand value of education and self-development
- To imbibe good values in students
- To know about the importanceof character

Values and self - development - Social values and individual attitude and work ethics, Indian vision of humanism - Moral and non- moral valuation - Standards and principles - Value judgements

Importance of cultivation of values, Sense of duty, Devotion, Self- reliance - Confidence, Concentration - Truthfulness, Cleanliness - Honesty, Humanity - Power of faith, National Unity - Patriotism - Love for nature, Discipline.

Personality and Behavior Development - Soul and Scientific attitude -Positive Thinking - Integrity and discipline - Punctuality, Love and Kindness - Avoid fault Thinking, Free from anger, Dignity of labour, Universal brotherhood and religious tolerance, True friendship, Happiness vs suffering, love for truth. Aware of self-destructive habits, Association and Cooperation, Doing best for saving nature

Character and Competence - Holy books vs Blind faith, Self-management and Good health, Science of reincarnation, Equality, Nonviolence, Humility, Role of Women, All religions and same message, Mind your Mind, Self-control, Honesty, Studying effectively.

REFERENCES

1. Chakroborty, S.K, “Values and Ethics for organizations Theory and practice”, Oxford University Press, New Delhi.

COURSE OUTCOMES

At end of the course work,Students will be able to

1. Acquire Knowledge of self-development.
2. Learn the importance of Human values
3. Develop the overall personality

23EEPSACXX	PEDAGOGY STUDIES	L	T	P	C
		2	0	0	0

COURSE OBJECTIVES

- Review existing evidence on the review topic to inform programmedesign and policy makingundertakenbythe DFID, other agencies and researchers.
- Identify critical evidence gaps to guidethe development.

INTRODUCTION AND METHODOLOGY

Aims and rationale, Policy background, Conceptual framework and terminology, Theories of learning, Curriculum, Teacher education - Conceptual framework, Research questions - Overview of methodology and Searching

THEMATIC OVERVIEW

Pedagogical practices are being used by teachers, in formal and informal classrooms in developing countries. Curriculum, Teacher education

EVIDENCE ON THE EFFECTIVENESS OF PEDAGOGICAL PRACTICES

Methodology for the in-depth stage: quality assessment of included studies. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? Theory of change - Strength and nature of the body of evidence for effective pedagogical practices - Pedagogic theory and pedagogical approaches -teachers attitudes and beliefs and Pedagogic strategies

Professional development: alignment with classroom practices and follow-up support, Peer support, Support from the head teacher and the community - Curriculum and assessment, Barriers to learning: limited resources and large class sizes.

RESEARCH GAPS AND FUTURE DIRECTIONS

Research design, Contexts, Pedagogy Teacher education, Curriculum and assessment, Dissemination, and research impact

REFERENCES

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2):245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3):361-379.
3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher Education research project (MUSTER) country report 1.London: DFID.

4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3):272–282.
5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary Education Oxford and Boston: Blackwell.
6. Chavan M (2003), Read India: A mass scale, rapid, learning to read campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.

COURSE OUTCOMES

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

1. Understand what pedagogical practices are being used by teachers in formal and informal classrooms in developing countries.
2. Understand what is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners
3. Learn how can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy.

23EEPSACXX	STRESS MANAGEMENT BY YOGA	L	T	P	C
		2	0	0	0

COURSE OBJECTIVES

- To achieve overall health of body and mind
- To overcome stress

Definitions of Eight parts of yoga. (Ashtanga) Yam and Niyam

1. Do`s and Don‘t‘s in life.
    a. Ahinsa, satya, astheya, bramhacharya and aparigraha
    b. Shaucha, santosh, tapa, swadhyay, ishwarpranidhan
2. Asan and Pranayam
    a. Various yoga poses and their benefits for mind &body
    b. Regularization of breathing techniques and its effects-Types of pranayam

REFERENCES

1. Yogic Asanas for Group Training-Part-I‖: Janardan Swami Yogabhyasi Mandal, Nagpur
2. Raja yoga or conquering the Internal Nature‖ by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata.

COURSE OUTCOMES

At the end of the course work the students will be able to

1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency

23EEPSACXX	PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS	L	T	P	C
		2	0	0	0

COURSE OBJECTIVES

- To learn to achieve the highest goal happily
- To become a person with stable mind, pleasing personality and determination
- To awaken wisdom in students

Neetisatakam-Holistic development of personality

- Verses- 19,20,21,22 (wisdom)
- Verses- 29,31,32 (pride &heroism)
- Verses- 26,28,63,65 (virtue)
- Verses- 52,53,59 (dont‘s)
- Verses- 71,73,75,78 (do‘s)

Approach to day to day work and duties Shrimad Bhagwad Geeta:

- Chapter 2-Verses 41,47,48,
- Chapter 3-Verses 13, 21, 27, 35,
- Chapter 6-Verses 5,13,17, 23,35,
- Chapter 18-Verses 45, 46, 48.

Statements of basic knowledge Shrimad Bhagwad Geeta:

- Chapter2-Verses 56, 62,68
- Chapter 12 -Verses 13, 14, 15, 16,17, 18

Personality of Role model.ShrimadBhagwadGeeta:

- Chapter2-Verses 17, Chapter 3-Verses36,37,42,
- Chapter 4-Verses 18,38,39
- Chapter18 -Verses37,38,63

REFERENCES

1. Srimad Bhagavad Gita‖ by Swami Swarupananda Advaita Ashram (Publication Department), Kolkata
2. Bhartrihari‘s Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit Sansthanam, NewDelhi.

COURSE OUTCOMES

At the end of the curse work the students will be able to

1. Study Shrimad - Bhagwad- Geeta that will help the student in developing his personality and achieve the highest goal in life
2. Lead the nation and mankind to peace and prosperity
3. Help in developing versatile personality

MANDATORY COURSES

23EEPSMCXX	CONSTITUTION OF INDIA	L	T	P	C
		2	0	0	0

COURSE OBJECTIVES

- Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
- Address the growth of Indian opinion regarding modern Indian intellectuals ‘constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.
- Address the role of socialism in India after the commencement of the Bolshevik revolution in 1917 and its impact on the initial drafting of the Indian Constitution.

HISTORY OF MAKING OF THE INDIAN CONSTITUTION

History, Drafting Committee, (Composition & Working)

PHILOSOPHY OF THE INDIAN CONSTITUTION

Preamble, Salient Features

CONTOURS OF CONSTITUTIONAL RIGHTS & DUTIES

Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

ORGANS OF GOVERNANCE

Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions

LOCAL ADMINISTRATION

District‘s Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation.

Pachayati raj: Introduction, PRI: Zila Pachayat, Elected officials and their roles, CEO Zila Pachayat: Position and role. Block level: Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed officials, Importance of grass root democracy.

ELECTION COMMISSION

Election Commission: Role and Functioning, Chief Election Commissioner and Election Commissioners, State Election Commission: Role and Functioning-Institute and Bodies for the welfare of SC/ST/OBC andwomen.

REFERENCES

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, Ist Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn, Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

COURSE OUTCOMES

At the end of the course work the students will be able to

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indianpolitics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct.
4. Familiarize with Elections through adult suffrage in the Indian Constitution.
5. Discuss the passage of the Hindu Code Bill of 1956.