ANNAMALAI UNIVERSITY

FACULTY OF ENGINEERING AND TECHNOLOGY

M.E. POWER SYSTEM

(Two-Year Full Time & Three-year Part Time)

DEGREE PROGRAM

Choice Based Credit System

Regulations & Curriculum – 2017

HAND BOOK

2017

DEPARTMENT OF ELECTRICAL ENGINEERING

M.E. / M. Tech (Two-Year Full Time & Three-year Part Time) DEGREE PROGRAM

CHOICE BASED CREDIT SYSTEM (CBCS)

REGULATIONS

1. Condition for Admission

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

2. Branches of Study in M.E / M.Tech

The Branch and Eligibility criteria of Programs are given in **Annexure 1**

3. Courses of study

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

4. Scheme of Examinations

The scheme of Examinations is given separately.

5. Choice Based Credit System (CBCS)

The curriculum includes three components namely Professional Core, Professional Electives and Open Electives in addition toThesis. Each semester curriculum shall normally have a blend of theory and practical courses.

6. Assignment of Credits for Courses

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

7. Duration of the Program

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

8. Registration for courses

A newly admitted student will automatically be registered for all the courses prescribed for the first semester, without any option. Every other student shall submit a completed registration form indicating the list of courses intended to be credited during the next semester. This registration will be done a week before the last working day of the current semester. Late registration with the approval of the Dean on the recommendation of the Head of the Department along with a late fee will be done up to the last working day. Registration for the Thesis Phase - I and II shall be done at the appropriate semesters.

9. Electives

The student has to select two electives in first semester and another two electives in the second semester from the list of Professional Electives. The student has to select two electives in third semester from the list of Open Electives offered by the department/ allied department. A student may be allowed to take up the open elective courses of third semester (Full Time program) in the first and second semester, one course in each of the semesters to enable them to carry out thesis in an industry during the entire second year of study provided they should register those courses in the first semester itself. Such students should meet the teachers offering those elective courses themselvesfor clarifications. No specific slots will be allotted in the time table for such courses.

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

10. Assessment

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

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

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

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

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

11. Student Counsellors (Mentors)

To help the students in planning their course of study and for general advice on the academic Program, the Head of the Department will attach a certain number of students to a member of the faculty who shall function as student counsellor for those students throughout their period of study. Such student counsellors shall advise the students, give preliminary approval for the courses to be taken by the students during each semester, monitor their progress in SWAYAM courses / open elective courses and obtain the final approval of the Head of the Department.

12. Class Committee

For each of the semesters of M.E / M.Tech Programs, separate class committees will be constituted by the respective Head of the Departments. The composition of the class committees from first to fourth semesters for Full time and first to sixth semesters for Part-time will be as follows:

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

- All counselors of the class and the Head of the Department (if not already a member) or any staff member nominated by the Head of the Department may opt to be special invitees.

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

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

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

13. Temporary Break of Study

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

14. Substitute Assessments

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

A student who wishes to have a substitute assessment for a missed assessment must apply to the Head of the Department within a week from the date of the missed assessment.

15. Attendance Requirements

The students with 75% attendance and above are permitted to appear for the University examinations. However, the Vice Chancellor may give a rebate / concession not exceeding 10% in attendance for exceptional cases only on Medical Grounds.

A student who withdraws from or does not meet the minimum attendance requirement in a semester must re-register and repeat the same semester in the subsequent academic years.

16. Passing and declaration of Examination Results

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

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 Program, the degree will be awarded with the following classifications based on CGPA.

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

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

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

18. Ranking of Candidates

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

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

19. Transitory Regulations

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

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

No.	Department		Program (Full Time & Part time)	Eligible B.E./B.Tech Program *
1	**Civil Engineering**	i.	Environmental Engineering	B.E. / B.Tech – Civil Engg, Civil & Structural Engg, Environmental Engg, Mechanical Engg, Industrial Engg, Chemical Engg, BioChemicalEngg, Biotechnology, Industrial Biotechnology, Chemical and Environmental Engg.
		ii.	Environmental Engineering & Management	
		iii.	Water Resources Engineering & Management	B.E. / B.Tech – Civil Engg, Civil & Structural Engg, Environmental Engg, Mechanical Engg, Agricuturalanf irrigation Engg, Geo informatics, Energy and Environmental Engg.
2	**Civil & Structural Engineering**	i.	Structural Engineering	B.E. / B.Tech – Civil Engg, Civil & Structural Engg.
		ii.	Construction Engg. and Management	
		iii.	Geotechnical Engineering	
		iv.	Disaster Management &Engg.	
3	**Mechanical Engineering**	i.	Thermal Power	B.E. / B.Tech – Mechanical Engg, Automobile Engg, Mechanical Engg (Manufacturing).
		ii.	Energy Engineering & Management	B.E. / B.Tech – Mechanical Engg, Automobile Engg, Mechanical (Manufacturing) Engg, Chemical Engg
4	**Manufacturing Engineering**	i.	Manufacturing Engineering	B.E. / B.Tech – Mechanical Engg, Automobile Engg, Manufacturing Engg, Production Engg, Marine Materials science Engg, Metallurgy Engg, Mechatronics Engg, Industrial Engg.
		ii.	Welding Engineering	
		iii.	Nano Materials and Surface Engineering	B.E. / B.Tech – Mechanical Engg, Automobile Engg, Manufacturing Engg, Production Engg, Marine Materials science Engg, Metallurgy Engg, Chemical Engg
5	**Electrical Engineering**	i.	Embedded Systems	B.E. / B.Tech – Electrical and Electronics Engg, Electronics and Instrumentation Engg,Control and Instrumentation Engg, Information technology, Electronics and communication Engg, Computer Science and Engg
		ii.	Smart Energy Systems	B.E. / B.Tech – Electrical and Electronics Engg, Electronics and Instrumentation Engg
		iii.	Power Systems	B.E. / B.Tech – Electrical and Electronics Engg

6	**Electronics & Instrumentation Engineering**	i.	Process Control & Instrumentation	B.E. / B.Tech – Electronics and Instrumentation Engg, Electrical and Electronics Engg, Control and Instrumentation Engg, Instrumentation Engg
		ii.	Rehabilitative Instrumentation	B.E. / B.Tech – Electronics and Instrumentation Engg, Electrical and ElectronicsEngg, Electronics and communication Engg, Control and Instrumentation Engg, Instrumentation Engg, Bio Medical Engg, Mechatronics.
		iii.	Micro Electronics and MEMS	B.E. / B.Tech – B.E. / B.Tech – Electronics and Instrumentation Engg, Electrical and ElectronicsEngg, Electronics and communication Engg, Control and Instrumentation Engg, Instrumentation Engg, Bio Medical Engg, Mechatronics, Telecommunication Engg
7	**Chemical Engineering**	i.	Chemical Engineering	B.E. / B.Tech – Chemical Engg, Petroleum Engg, Petrochemical Technology
		ii.	Food Processing Technology	B.E. / B.Tech - Chemical Engg, Food Technology, Biotechnology, Biochemical Engg, Agricultural Engg.
		iii.	Industrial Bio Technology	B.E. / B.Tech - Chemical Engg, Food Technology, Biotechnology, Leather Technology
		iv.	Industrial Safety Engineering	B.E. / B.Tech – Any Branch of Engineering
8	**Computer Science & Engineering**	1.	Computer Science & Engineering	B.E. / B.Tech - Computer Science and Engineering, Information Technology, Electronics and Communication Engg, Software Engineering
9	**Information Technology**	i	Information Technology	B.E. / B.Tech - Computer Science and Engineering, Information Technology, Electronics and Communication Engg, Software Engineering
10	**Electronics & Communication Engineering**	i.	Communication Systems	B.E. / B.Tech - Electronics and Communication Engg, Electronics Engg.

*** AMIE in the relevant discipline is considered equivalent to B.E**

DEPARTMENT OF ELECTRICAL ENGINEERING

Vision - Mission Statement

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.

M.E. (POWER SYSTEMS)

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 (PO)

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

PO 1: Engineering Knowledge:

Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO 2: Problem Analysis:

Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO 3: Design/Development of Solutions:

Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO 4: Conduct Investigations of Complex Problems:

Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO 5: Modern Tool Usage:

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

PO 6: The Engineer and Society:

Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO 7: Environment and Sustainability:

Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO 8: Ethics:

Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO 9: Individual and Team Work:

Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO 10: Communication:

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

PO 11: Project Management and Finance:

Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO 12: Life-Long Learning:

Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSO)

PSO 1: Inculcate research attitude and develop innovative methodologies independently to solve Power System problems

PSO 2: Inscribe and be exposed with significant technical reports / documents in the domain of Power System Engineering

PSO 3 : Demonstrate an acceptable degree of mastery with an exposure to the state-of-the-art practices for employability / higher education.

Mapping PO with PEO															
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
PEO 1	3	3	3	3		2					1	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 for M.E. Power Systems (Full-Time)

Sl. No.	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits
	Semester - I									
1	PC-I	PSEC101	Applied Mathematics	4	-	-	25	75	100	3
2	PC-II	PSEC102	Computer aided Power System Analysis	4	-	-	25	75	100	3
3	PC-III	PSEC103	State Estimation and Security Control of Power Systems	4	-	-	25	75	100	3
4	PC-IV	PSEC104	Extra High Voltage AC and DC Transmission	4	-	-	25	75	100	3
5	PE-I	PSEE105	Professional Elective-I	4	-	-	25	75	100	3
6	PE-II	PSEE106	Professional Elective-II	4	-	-	25	75	100	3
7	PC Lab-I	PSEP107	Power System Simulation and Analysis Laboratory-I	-	-	3	40	60	100	2
			Total	**24**		**3**	**190**	**510**	**700**	**20**

Sl. No.	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits
	Semester - II									
1	PC-V	PSEC201	Power System Operation and Control	4	-	-	25	75	100	3
2	PC-VI	PSEC202	Power System Protection	4	-	-	25	75	100	3
3	PC-VII	PSEC203	Restructured Power Systems	4	-	-	25	75	100	3
4	PC-VIII	PSEC204	Power System Stability	4	-	-	25	75	100	3
5	PE-III	PSEE205	Professional Elective-III	4	-	-	25	75	100	3
6	PE-IV	PSEE206	Professional Elective-IV	4	-	-	25	75	100	3
7	PCLab-II	PSEP207	Power System Simulation and Analysis Laboratory-II	-	-	3	40	60	100	2
8	Semin	PSES208	Seminar	-	-	2	100	-	100	1
			Total	**24**		**5**	**290**	**510**	**800**	**21**

Sl. No.	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits
	Semester - III									
1	OE-I	PSEE301	Open Elective-I	4	-	-	25	75	100	3
2	OE-II	PSEE302	Open Elective-II	4	-	-	25	75	100	3
3	Thesis	PSET303	Thesis Phase-I	-	4	-	40	60	100	4
4	Ind Train	PSEI304	Industrial Training	-	*	-	100	-	100	2
			Total	**8**	**4**	**-**	**190**	**210**	**400**	**12**

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

Sl. No.	Category	Course Code	Course	L	T	P	CA	FE	Total		Credits
		Semester - IV									
1	Thesis	PSET401	Thesis Phase-II	-	8	-	40	60	100		12
			Total	**-**	**8**	**-**	**40**	**60**	**100**		**12**

L- Lecture ;**P**-Practical ; **T**-Thesis ; **CA**-Continuous Assessment; **FE**-Final Exam

Curriculum for M.E. Power Systems (Part-Time)

Sl. No.	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits	Equivalent Course Code in M.E. Full Time
		Semester – I									
1	PC-I	PPSEC101	Applied Mathematics	4	-	-	25	75	100	3	PSEC101
2	PC-II	PPSEC102	Computer aided Power System Analysis	4	-	-	25	75	100	3	PSEC102
3	PC-III	PPSEC103	State Estimation and Security Control of Power Systems	4	-	-	25	75	100	3	PSEC103
			Total	**12**	**-**	**-**	**75**	**225**	**300**	**09**	

Sl. No.	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits	Equivalent Course Code in M.E. Full Time
		Semester – II									
1	PC-IV	PPSEC201	Power System Operation and Control	4	-	-	25	75	100	3	PSEC201
2	PC-V	PPSEC202	Power System Protection	4	-	-	25	75	100	3	PSEC202
3	PC-VI	PPSEC203	Restructured Power Systems	4	-	-	25	75	100	3	PSEC203
			Total	**12**	**-**	**-**	**75**	**225**	**300**	**09**	

Sl. No.	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits	Equivalent Course Code in M.E. Full Time
		Semester – III									
1	PC-IV	PPSEC301	Extra High Voltage AC and DC Transmission	4	-	-	25	75	100	3	PSEC104
2	PE-I	PPSEE302	Professional Elective-I	4	-	-	25	75	100	3	PSEE105
3	PE-II	PPSEE303	Professional Elective-II	4	-	-	25	75	100	3	PSEE106
4	PC Lab-I	PPSEP304	Power System Simulation and Analysis Laboratory-I	-	-	3	40	60	100	2	PSEP107
			Total	**12**	**-**	**3**	**115**	**285**	**400**	**11**	

sl. No.	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits	Equivalent Course Code in M.E. Full Time
		Semester – IV									
1	PC-VIII	PPSEC401	Power System Stability	4	-	-	25	75	100	3	PSEC204
2	PE-III	PPSEE402	Professional Elective-III	4	-	-	25	75	100	3	PSEE205
3	PE-IV	PPSEE403	Professional Elective-IV	4	-	-	25	75	100	3	PSEE206
4	PC Lab-II	PPSEP404	Power System Simulation and Analysis Laboratory-II	-	-	3	40	60	100	2	PSEP207
5	Semin	PPSES405	Seminar	-	-	2	100	-	100	1	PSES208
			Total	**12**	**-**	**5**	**215**	**285**	**500**	**12**	

Sl. No.	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits	Equivalent Course Code in M.E. Full Time
		Semester – V									
1	OE-I	PPSEE501	Open Elective-I	4	-	-	25	75	100	3	PSEE301
2	OE-II	PPSEE502	Open Elective-II	4	-	-	25	75	100	3	PSEE302
3	Thesis	PPSET503	Thesis Phase-I	-	4	-	40	60	100	4	PSET303
4	Ind Train	PPSII 504	Industrial Training	-	*	-	100		100	2	PSEI304
			Total	**8**	**4**	**-**	**190**	**210**	**400**	**12**	

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

Sl. No.	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits	Equivalent Course Code in M.E. Full Time
		Semester – VI									
1	Thesis	PPSET601	Thesis Phase-II	-	8	-	40	60	100	12	PSET401
			Total	**-**	**8**	**-**	**40**	**60**	**100**	**12**	

L- Lecture ;**P**-Practical ; **T**-Thesis ; **CA**-Continuous Assessment; **FE**-Final Exam

PE – PROFESSIONAL ELECTIVES

1. Flexible Ac Transmission Systems
2. Smart Grid
3. Wind and Solar Energy Systems
4. Energy Management and Energy Audit
5. Distributed Generation and Microgrids
6. Solid State Controlled Electric Drives
7. Power System Dynamics
8. Power System Transients
9. Power System Reliability
10. Power Quality Studies
11. Systems Theory
12. Electrical Distribution Systems

OE-OPEN ELECTIVES

1. Soft Computing Techniques
2. Optimization Techniques
3. Cloud Computing
4. Scientific Research and Technical Communication
5. Internet of Things
6. Intellectual Property Rights

PSEC101	APPLIED MATHEMATICS	L	T	P
		4	0	0

COURSE OBJECTIVES:

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

Matrices

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

Operations Research

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

Statistics

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

Boundary Value Problems

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

Partial Differential Equations:

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

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4. Venkataraman. M.K,"Higher Mathematics for Engineering &Science", TheNational Publishing Co. 1992.

5. Erwin Kreyszig, "Advanced Engineering Mathematics", WileyEastern, 2015.
6. Louis Pipes .A and Hartill, "Applied Mathematics for Engineers and Physicists", McGraw Hill., 2014.

COURSE OUTCOMES:

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

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

Mapping with Program Outcomes

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

PSEC102	COMPUTER AIDED POWER SYSTEM ANALYSIS	L	T	P
		4	0	0

COURSE OBJECTIVES:

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

Modelling of Power System

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

Sparsity Techniques

Sparse systems - Theorems of sparse matrix - Strategies for reducing bandwidth of matrices – Direct solution of sparse network equations by optimally ordered triangular factorization – Sparsity and optimal ordering.

Power Flow Studies

Power flow model using bus admittance matrix – Review of power flow algorithms – Gauss-Seidal method, Newton-Raphson method and Fast decoupled power flow method- AC-DC power flow analysis – Multiarea power flow analysis with tie-line control – Harmonic power flow – Three phase power flow – Distribution power flow – 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.

Stability Studies

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

REFERENCES:

1. Arrillaga.J and Watson.N.R, “Computer Modelling of Electrical Power Systems”, Wiley publishers, 2001.
2. Pai M.A, “Computer Techniques in Power System Analysis”, Tata McGraw Hill, 2006.

3. George Kusic, "Computer Aided Power System Analysis", CRC Press, 2009.
4. Kothari D.P and Nagrath I.J, "Modern Power system analysis", Tata McGraw Hill, 2011.
5. Stagg G.Wand El- Abiad .A.H, "ComputerMethods inPower SystemAnalysis" McGraw Hill Book Co,1983.
6. Singh L.P, "Advanced power system analysis and dynamics", New age international publishers, 2012.

COURSE OUTCOMES:

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

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

Mapping with Program Outcomes															
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	1	1										2	1
CO2	2	3	1										2	1	
CO3	1	1	1									2	2		2
CO4	3	2	2												2
CO5	3	3	1											2	2

PSEC103	STATE ESTIMATION AND SECURITY CONTROL OF POWER SYSTEMS	L	T	P
		4	0	0

COURSE OBJECTIVES:

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

Introduction

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

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 Attilio Pegoraro, 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 this course, 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 enhancement strategies.

Mapping with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3											2			
CO2	3	2		2						3			3		2
CO3	3	2										2	3	2	1
CO4	3		2				2			3					1
CO5	3	2										2	3		

PSEC104	EXTRA HIGH VOLTAGE AC AND DC TRANSMISSION	L	T	P
		4	0	0

COURSE OBJECTIVES:

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

Introduction

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

EHV AC Transmission

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

HVDC Transmission

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

EHV lines and Cable Transmission

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

Testing, Overvoltage and Design of EHV Systems

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; 2nd edition, 2008.

COURSE OUTCOMES:

At the end of this course, 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 EHV system.

Mapping with Program Outcomes															
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2														2
CO2	3	2											1		
CO3	2	2													3
CO4	1		3												2
CO5		2	3										2		

PSEP107	POWER SYSTEM SIMULATION AND ANALYSIS LABORATORY-I	L	T	P
		0	0	3

COURSE OBJECTIVES:

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

LIST OF EXPERIMENTS:

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

COURSE OUTCOMES:

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

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

Mapping with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	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						1		1		2		3
CO5	2		2		3								2	2	2

PSEC201	POWER SYSTEM OPERATION AND CONTROL	L	T	P
		4	0	0

COURSE OBJECTIVES:

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

Economic Operation of Power Systems

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 Dispatchwith Transmission Losses - Gradient Methods of Economic Dispatch - Newton's Method.

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 Power Systems",2009
7. Elgerd.O.I, "Electric Energy Systems: Theory – An Introduction", Tata McGraw Hill, New Delhi, 2001.

COURSE OUTCOMES:

At the end of this course, 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**	**PO12**	**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	

PSEC202	POWER SYSTEM PROTECTION	L	T	P
		4	0	0

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

Overcurrent protection-types of overcurrent relay-over current protective schemes-protection of feeders and ring mains- directional over-current relay- drawbacks of over-current relays- earth fault and phase fault protection - combined earth fault and phase fault protection scheme - phase fault protective scheme- directional earth fault relay- static over current relays

Transformer Protection

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

Protection of Transmission Lines

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

Generator and Induction Motor Protection

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

Substation Automation

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

REFERENCES:

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

COURSE OUTCOMES:

At the end of this course, 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 Program 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

PSEC203	RESTRUCTURED POWER SYSTEMS	L	T	P
		4	0	0

COURSE OBJECTIVES:

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

Introduction to Restructuring of Power Industry

Reasons for restructuring of power industry-Vertically Integrated Utilities and Power Pools-Different Entities involved-Market models-Benefits from a Competitive Electricity Market-Role of the Independent System Operator (ISO)- Operational Planning Activities of ISO- The ISO in Pool Markets- The ISO in Bilateral Markets-Worldwide Movement of Power Industry Restructuring

Transmission Congestion Management

Introduction-Definition of congestion- reasons for transfer capability limitation-importance of congestion management- features of congestion management – classification of congestion management methods- Bid, Zonal and Node congestion principles – Inter zonal and intra zonal congestion – Generation rescheduling – Transmission congestion contracts.

Transmission Open Access and Pricing

Power Wheeling- Transmission Open Access- Types of Transmission Services in Open Access-Power Trading- Cost Components in Transmission- Pricing of Power Transactions-Locational marginal pricing - Embedded Cost Based Transmission Pricing - Incremental Cost Based Transmission Pricing.

Ancillary Services Management

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

Reforms in Indian Power Sector

Introduction – Framework of Indian power sector – Reform initiatives – Salient features of Indian Electricity Act 2003 –IEGC- Transmission system operator – Power Exchange – Regulatory and policy development in Indian power sector- opportunities for IPP and capacity power producer – Availability based tariff.

REFERENCES:

1. K Bhattacharya, M Bollen, JE Daalder, “Operation of Restructured Power Systems”, Kluwer academic publishers, 2001.
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, India, 2008.
4. Mohammad Shahidehpour and MuwaffaqAlomoush, “Restructured Electric Power System operation trading and volatility”, Marcel Dekker Inc,2001.
5. Loi Lei Lai,“Power System Restructuring and Deregulation”, John Wiley & Sons Ltd, England, 2001.
6. Xiao-Ping Zhang, “Restructured Electric Power Systems: Analysis of Electricity Markets with Equilibrium Models”, John Wiley & Sons, 2010.

COURSE OUTCOMES:

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

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

Mapping with Program Outcomes

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

PSEC204	POWER SYSTEM STABILITY	L	T	P
		4	0	0

COURSE OBJECTIVES:

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

Introduction to Power System Stability

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

Synchronous Machine Representation in Stability Studies

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

Small Signal Stability

State space representation – Eigen values - Modal matrices - Small signal stability of single machine 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 - Factors influencing transient stability - Review of numerical integration methods -Modified Euler's method and 4^{th} order Runge-Kutta method - Transient stability enhancement methods – High speed fault clearing – Steam turbine fast valving - High speed excitation systems

Voltage Stability Analysis

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

REFERENCES:

1. KundurP,"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 this course, the students will be able to

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

Mapping with Program Outcomes															
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2										3		3
CO2	3	2											2		2
CO3	3	2	1										2		2
CO4	2												2		1
CO5	3	2	2										2		2

PSEP207	POWER SYSTEM SIMULATION AND ANALYSIS LABORATORY-II	L	T	P
		0	0	3

COURSE OBJECTIVES:

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

LIST OF EXPERIMENTS:

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

COURSE OUTCOMES:

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

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

Mapping with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	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						1		1		2		3
CO5	2		2		3								3	2	2

PSES208	SEMINAR	L	T	P
		0	0	2

COURSE OBJECTIVES:

- To work on a technical topic related to Power Systems and acquire the ability of written and oral presentation
- To acquire the ability of writing technical papers for Conferences and Journals

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

COURSE OUTCOMES:

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

1. Train themselves to face the audience and to interact confidently with the audience
2. Tackle any problem during group discussion in the corporate interviews.
3. Acquire sufficient communication skills through oral presentation.
4. Develop applied mathematical skills in justifying their technical topic and provide a base for draft for technical report and documentation.
5. Manipulate available data genuinely to achieve their objectives and goal.

Mapping with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1		2							2	1			2		
CO2		1							1	1					
CO3										2					
CO4				2	2						1		1	2	
CO5				1	1						2			1	

PSET303	THESIS WORK PHASE – I	L	T	P
		0	4	0

COURSE OBJECTIVES:

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

METHOD OF EVALUATION:

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

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

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

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

COURSE OUTCOMES:

At the end of this course, 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	PO12	PSO1	PSO2	PSO3
CO1	3						3	1				1	1	2	
CO2	3	2	3	2	2			2					1		
CO3	2	1		1	1					1	1	2	2	1	
CO4	3									1	3				2
CO5	2									2					1

PSEI304	INDUSTRIAL TRAINING	L	T	P
		0	*	0

COURSE OBJECTIVES:

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

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

COURSE OUTCOMES:

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

1. Face the challenges in the field with confidence.
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	PO12	PSO1	PSO2	PSO3
CO1	3	2		2		2	2		1		1		2	2	2
CO2	2			2		2			1				2		2
CO3				2		2			1	2	1		2	1	1
CO4						1			2	2	1			1	1
CO5	2	2	2			1	1						1		1

PSET401	THESIS WORK PHASE – II	L	T	P
		0	8	0

COURSE OBJECTIVES:

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

METHOD OF EVALUATION:

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

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

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

COURSE OUTCOMES:

At the end of this course, 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	PO12	PSO1	PSO2	PSO3
CO1	3												3		
CO2	3	3	3	3									2		
CO3	2			1	3								1		1
CO4	3							2		3				3	
CO5	2									3					3

PSEEX0X	FLEXIBLE AC TRANSMISSION SYSTEMS (FACTS)	L	T	P
		4	0	0

COURSE OBJECTIVES:

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

Introduction

Reactive Power Control in AC Transmission lines – Uncompensated transmission line – Need for Controllers – Basic types of Controllers - shunt compensated controller – series compensated controller – Thyristor controlled voltage regulator – comparison of HVDC and FACTS technologies.

Static VAr Compensators (SVC)

Objectives of shunt compensation - Methods of controllable VAr Generation - Merits of Hybrid compensators - General control scheme of static VAr compensator – VI and VQ Characteristics of SVC – Voltage control by SVC – Influence of SVC on system voltage – Design of SVC voltage regulator.

Static Series Compensators (SSC)

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

Emerging FACTS Controllers

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

Co-ordination of FACTS Controllers

Controller interactions –SVC – SVC interaction - Co-ordination of multiple Controllers using linear Control techniques - Unified Power Flow Controller(UPFC) – Independent real and reactor Power flow Control – Control Schemes for P and Q Control – Interline Power flow Controller(IPFC) – Control Structure - Design of FACTS Controllers- The Basic Procedure for Controller Design- Derivation of the System Model- Enumeration of the System PerformanceSpecifications-Selection of the Measurement and Control Signals -Controller Design and Coordination-Validation of the Design and Performance Evaluation.

REFERENCES:

1. Narain G. Hingorani, Laszio.Gyugy, “Understanding FACTS Concepts and Technology of Flexible AC Transmission Systems”, Standard Publishers Distributor, NewDelhi ,2001.
2. Narain G. Hingorani,“High power Electronics and Flexible AC Transmission Systems”, IEEE High Power Engineering Review,1998.
3. Mohan Mathur. R,Rajiv. K.Varma, “Thyristor Based FACTS Controller for Electrical transmission Systems”, IEEE press ,John Wiley and Sons, 2002.
4. John .A.T, “ Flexible AC Transmission System” , IEEE 1999.
5. Singh.S.N , “ Electric Power Generation Transmission and Distribution”, PHI, New Delhi 2003.

COURSE OUTCOMES:

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

1. Acquaint with new methods adopted in power system control.
2. Model and develop new devices needed for reactive power control.
3. Familiarize with quantitative treatment of all types of FACTS controllers.
4. Equip with basic procedure of FACTS controller Design.
5. Develop controller design**.**

Mapping with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1					1						3		
CO2	3	2					2		2				3		
CO3	3		2		2				1				2	2	
CO4	3		3		2							2	2	1	
CO5	3		2									2	3	1	

PSEEX0X	SMART GRID	L	T	P
		4	0	0

COURSE OBJECTIVES:

- To familiarize with the fundamentals of smart grids
- To get exposed to Smart Grid technologies, functionalities and capabilities
- To study about the performance analysis tools for smart grid
- To know about the various stability assessment tools for smart grid
- To focus on smart metering and demand-side integration
- To familiarize with the application of FACTS and Energy storage devices in smart grid

Introduction

Motivation for smart grid- smart grid Definition -benefits- Comparison of Traditional Grid and Smart Grid-Characteristics of a Smart Grid -Stakeholders in smart grid development- Smart grid technology framework , functionalities and capabilities- Cost Components for the Smart Grid: Transmission Systems and Sub-Stations End- Distribution End- Consumer End- Cost-Benefit Analysis

Load Flow and Contingency Analysis for Smart Grid

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

Stability Assessment for Smart Grid

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.

REFERENCES:

1. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, JianZhong Wu, Akihiko Yokoyama, “Smart Grid: Technology and Applications”, John Wiley & Sons, 2012.

2. James Momoh, "Smart Grid: Fundamentals of design and analysis", John Wiley & sons Inc, 2012.
3. Krzysztof Iniewski, "Smart Grid Infrastructure & Networking", Tata McGraw Hill, 1st edition, 2012.
4. Stuart Borlase,"Smart Grids: Infrastructure, Technology, and Solutions", CRC press, 2013.
5. SawanSen ,SamarjitSengupta, AbhijitChakrabarti , "Electricity pricing- regulated, deregulated and smart grid systems", CRC press, 2015.
6. Mini S. Thomas and John Douglas McDonald, "Power system SCADA and smart grids", CRC press, 2015.

COURSE OUTCOMES:

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

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

Mapping with Program Outcomes

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

PSEEX0X	WIND AND SOLAR ENERGY SYSTEMS	L	T	P
		4	0	0

COURSE OBJECTIVES:

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

Introduction

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

Wind Electric Generators

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

Solar collectors – Types of solar collectors – Solar air heaters – Types of solar air heaters – Applications of solar air heaters – 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

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

REFERENCES:

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. SirajAhamed, “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 this course, 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. Familiarize with the various types of solar collectors and its storage.
5. Understand the basic knowledge of photo voltaic system.

Mapping with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2		3			2	2						2	2	1
CO2	3	3	2	2		2	2						2	2	1
CO3	3	2	2	2											
CO4	2	1	2			2	2						2		
CO5	3	2	2			2	2						2	2	1

PSEEX0X	ENERGY MANAGEMENT AND ENERGY AUDIT	L	T	P
		4	0	0

COURSE OBJECTIVES:

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

Introduction

Basics of Energy and its various forms - Conventional and Non- conventional sources - Energy policy - Energy conservation act 2001 - Energy managers and energy auditors - Roles and responsibility of energy managers - Energy labelling and energy standards.

Energy Management

Supply side and demand side management - Energy management methods, Energy management systems - Energy monitoring - Energy review and energy bench marking - Energy performance - maximizing system efficiencies - Optimizing the input energy requirements - Energy action planning.

Energy Audit

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

Energy Assessment and Reporting

Evaluation of saving opportunities – Determining the savings in INR - Noneconomic factors - Conservation opportunities, estimating cost of implementation - Energy audit reporting - Plant energy study report, importance - Effective organization - Report writing and presentation.

Energy Economics

Energy economics - Depreciation - Financial analysis techniques - Discount rate, Payback period, Internal rate of return, Net present value, Life cycle costing – Energy Service Company (ESCO) concept – Cumulative Sum (CUSUM) technique - ESCO contracts.

REFERENCES:

1. Wayne C. Turner, Steve Doty, “Energy Management Handbook”, CRC press, Taylor & Frances group, Eighth Edition, 2012.
2. Barney L. Capehart, Wayne C. Turner, William J. Kennedy, “Guide to Energy Management”, CRC press, Taylor & Frances group, Eighth Edition, 2016.
3. Thumann, P.E, William J. Younger, “Hand Book of Energy Audits”, CRC press, Taylor & Frances group, Seventh Edition, 2007.

4. L.C. Witte, P.S. Schmidt, D.R. Brown, "Industrial Energy Management and Utilization", Hemisphere Publication, Washington, 1988.
5. Astop T.D & Croft D.R, "Energy Efficiency for Engineers and Technologists", Scientific& Technical, Longman, 1990.

COURSE OUTCOMES:

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

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

Mapping with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	2			2	2						2	2	1
CO2	2	2	1	2		2	2						2	2	1
CO3	2	2	1	1		2	2						2	2	1
CO4	3	2	2	2		2	2						2	2	1
CO5	3	2	2	1		2	2						2	2	1

PSEEX0X	DISTRIBUTED GENERATION AND MICROGRIDS	L	T	P
		4	0	0

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 Co-ordination 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 this course, 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	PO12	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

PSEEX0X	SOLID STATE CONTROLLED ELECTRIC DRIVES	L	T	P
		4	0	0

COURSE OBJECTIVES:

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

DC Drives

Introduction-fundamentals of electric drives- comparison between conventional and solid state drives-open loop and closed loop speed control- motor transfer function-speed and current loops-load torque disturbance

Separately excited D.C motor and series motor drive-waveforms – equations-performance characteristics -operation of semi and full converters- reversible drives using dual converters-armature and field current reversal

Chopper Controlled Drives (Using Devices Other Than Thyristors)

Chopper fed D.C motors, analysis and performance characteristics-Dynamic and regenerative braking of chopper controlled drives-regenerative reversals-transit systems.

Induction Motor Drives

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

Synchronous Motor Drives

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

Special Machines Drives

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

REFERENCES:

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 this course, the students will be able to

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

Mapping with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	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	

PSEEX0X	POWER SYSTEM DYNAMICS	L	T	P
		4	0	0

COURSE OBJECTIVES:

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

Introduction

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

Machine Modelling and Machine Controllers

Electromagnetic Model of Synchronous Generator - Park Equations - equivalent circuits for the d- and q-Axes - steady-state operation - detailed model in dynamic state - modelling of the Induction Motor - basic equations in the d–q Reference Frame - steady-state operation - exciter and voltage regulator - function of excitation systems - typical excitation system configuration - saturation function - stabilising 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 - types of turbines and governing systems for steam turbines - gas turbines - combined-cycle power plants - 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 turbine system - DFIG Model.

Active Power Flow Control

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

Reactive Power Flow Control

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 modeling - tertiary voltage regulation - block diagram with the excitation system, analysis of effect of AVR on synchronizing and damping components - Power System Stabilizer: block diagram of PSS with description - delta-omega and delta P-omega stabilizers - Frequency-based stabilizers - Digital Stabilizer - stabilizing signal washout stabilizer gain - stabilizer limits.

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. AbhijitChakrabarti, "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, NewDelhi, 2014.

COURSE OUTCOMES:

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

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

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

PSEEX0X	POWER SYSTEM TRANSIENTS	L	T	P
		4	0	0

COURSE OBJECTIVES:

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

Travelling Waves

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

Switching Transients

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

Lightning-induced Transients

The Mechanism of Lightning- Wave shape of the Lightning Current- Direct Lightning Stroke to Transmission Line Towers- Direct Lightning Stroke to a Line.

Modeling of Power Apparatus

Modeling of Transformers- Modeling of Generators- Modeling of Motors- Models for an overhead transmission line- Models for cables- Modeling of Steel cores- Miscellaneous components.

Insulation Coordination

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

REFERENCES:

1. Allan Greenwood, “Electrical Transients in Power Systems”, Wiley Inter Science, New York, 1971.
2. C.S.Indulkar, DP Kothari, “Power System Transients” – A Statistical approach, Prentice Hall, 1996.
3. Bewley, L..V., “Travelling Waves on Transmission System”, Power Publications Inc. 1993.

4. Akihiro Ametani, Naoto Nagaoka, Yoshihiro Baba, Teruo Ohno, "Power System Transients: Theory and Applications", CRC Press, 2013.
5. Lou van der Sluis, "Transients in Power Systems", John Wiley & Sons, 2001.
6. Arrillaga. J and Watson.N.,"Power systems Electromagnetic Transients simulation", The Institution of Engineering and Technology, London, 2007.

COURSE OUTCOMES:

At the end of this course, 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	PO12	PSO1	PSO2	PSO3
CO1	3	3	2					2					2		
CO2	3	2	3	2				2					3	2	
CO3	3	2		2				2					2	2	
CO4	3	3	3					2					2		
CO5	3	2	2					2					3		2

PSEEX0X	POWER SYSTEM RELIABILITY	L	T	P
		4	0	0

COURSE OBJECTIVES:

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

Introduction

Definition of Reliability and Failure - Bathtub Curve - Concepts of Probability- Evaluation Techniques: Markov Process, Recursive Technique - Security levels of system – Reliability cost – Adequacy indices – Functions of system security – Contingency analysis – Linear sensitivity factors- Hierarchical Levels in Power System Reliability Assessment.

Generating Capacity: Basic Probability Methods

Generation system models –Capacity outage probability tables – Loss of load indices – Equivalent forced outage rate – Capacity expansion analysis – Scheduled outages – Evaluation methods on period basis– Loss of energy indices.

Generating Capacity: Frequency and Duration Method

Introduction – Generation model with no derated states– System risk indices with individual and cumulative load model– Practical system studies.

Composite Generation and Transmission System

Introduction – Radial configurations – Conditional probability approach – Network configurations – State selection – System and load point indices – Application to practical system – Data requirements for composite system reliability evaluation.

Distribution System

Introduction – Evaluation techniques –Interruption indices: Customer oriented, Load and Energy oriented – Application to radial systems – Effects of lateral distributor protection, disconnects, protection failures and transferring loads – Probability distribution of reliability indices.

REFERENCES:

1. Roy Billinton, R.N. Allan, “Reliability Evaluation of Power Systems”, Springer, 1996.
2. Ali Chowdhury, Don Koval, “Power Distribution System Reliability: Practical Methods and Applications”, Wiley-IEEE Press, 2009.
3. Cepin, Marko, “Assessment of Power System Reliability”, Springer, 2011.
4. Dr.K.UmaRao, “Power system operation & control”, Wiley-India, First edition, 2013.
5. M.V.F. Pereira, N.J. Balu, “Composite generation/transmission reliability evaluation”, Proceedings of the IEEE, Vol. 80, No. 4, pp. 470-491, 1992.

COURSE OUTCOMES:

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

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

Mapping with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3		3										2		
CO2	3												1		
CO3	3	2	1										3		
CO4	3	3											2		
CO5	3	3	2										2		

PSEEX0X	**POWER QUALITY STUDIES**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES:

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

Introduction to Power Quality

Definition of Power Quality – Causes of disturbances in Power Systems – Classification of Power Quality Issues – Formulations and Measures used for Power Quality - Harmonics – Average value of non-sinusoidal waveform – RMS value of a non-sinusoidal waveform – From factor – Ripple factor - Harmonic factor – Lowest order Harmonic – Total Harmonic Distortion – Total Inter-harmonic Distortion – Total Sub-harmonic Distortion – Total demand Distortion – Telephone influence factor – C-message weights – V.T and I.T products – Telephone form factor – Distortion index – Distortion Power - Effect of Poor Power Quality on Power System Devices – Power Acceptability Curves – Standards and Guidelines Referring to Power Quality – IEEE – IEC Standards.

Analysis and Conventional Mitigation Methods

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

Harmonics: Types of nonlinear loads – Harmonic Distortion – Voltage and Current Distortion – Harmonic indices – Harmonic sources from commercial and industrial loads – Locating Harmonic Sources – Harmonic Distortion Evaluation – Concept of Point of Common Coupling – Principles of Controlling Harmonics – Reducing Harmonic Currents in Loads – Development of a System Model – Modelling Harmonic Sources - Computer tools of Harmonic Analysis.

Harmonic Filters

Devices for Controlling Harmonic Distortion: Passive filters – Filter Transfer Function – Common types of Passive Filters for Power Quality Improvement – Classification of Passive Filters – Potential and Limitations of Passive Filters – Application of Hybrid Passive Filter Design to improve the Power Quality of the IEEE 30-Bus Distribution System feeding Adjustable Speed Drives - Active Filters - Hybrid Filters – Application of Hybrid of Passive and Active Filters for Harmonic Mitigation of Six Pulse and Twelve Pulse Rectifier Loads.

Power Quality Improvement

Unified Power Quality Conditioner – UPQC control System – UPQC control using the Park (DQO) Transformation – UPQC control based on the Instantaneous real and imaginary Power Theory – Performance of UPQC - Custom Power Park.

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

Reactive Power Compensation – Benefits and Drawbacks – Common types of Distribution Shunt Capacitor Banks – Classification of Capacitor Allocation Techniques for Sinusoidal Operating Conditions – Analytical methods – Numerical Programming methods.

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

REFERENCES:

1. Roger C. Dugan, Mark F. Mcgranaghan, Surya Santoso and H. Wayne Beaty, “Electrical Power Systems Quality”, Third Edition, Tata McGraw Hill, 2012.
2. ArindamGhosh and Gerard Ledwich, “Power Quality Enhancement using Custom Power Devices”, Kluwer Academic Publishers, 2002.
3. Mohammad A.S. Masoum and Ewald F. Fuchs, “Power Quality in Power Systems and Electrical Machines”, Second Edition, Elsevier, 2015.
4. Bhim Singh, Ambrish Chandra and Kamal Al-Haddad, “Power Quality Problems and Mitigation Techniques”, John Wiley and Sons, 2015.
5. Alexander Kusko and Marc T. Thompson, “Power Quality Electrical Systems”, McGraw Hill, 2007.

COURSE OUTCOMES:

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

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

Mapping with Program Outcomes															
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1	1	1	1							2	1	1
CO2	3	2	2	1	1	1							2	1	1
CO3	3	2	2	1	1	1							2	1	1
CO4	2	2	2	1	1	1							2	1	1
CO5	2	2	2	2	2								2	1	1

PSEEX0X	SYSTEMS THEORY	L	T	P
		4	0	0

COURSE OBJECTIVES:

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

Basics of Design Concepts

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

State Variable Representation

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

Controllability and Observability

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

Stability Analysis

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

Modal Control

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

REFERENCES:

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, 2005.
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 this course, 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 about modal control concepts.

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

PSEEX0X	ELECTRICAL DISTRIBUTION SYSTEMS	L	T	P
		4	0	0

COURSE OBJECTIVES:

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

Distribution Systems

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

Control and Protection

Voltage control: Application of shunt capacitance for loss reduction – Harmonics in the system – Static VAR systems – Voltage profile enhancement schemes.
System protection: Fuses and section analyzers - Over current protection - Under voltage and under frequency protection – Coordination of protective device.

Reliability Analysis

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

Distribution Automation

Definitions – Automation switching control – Management information systems (MIS) – Remote terminal units – Communication methods for data transfer – Consumer information service (CIS) – Graphical information systems (GIS) - Automatic meter reading (AMR) – Remote control load management. Substation automation – Requirements – Control aspects in substations – Feeder automation – Consumer side automation.

Expansion Planning

Distribution system planning: Short term planning - Long term planning - dynamic planning - Sub-transmission and substation design. Sub-transmission networks configurations - Substation bus schemes - Distribution substations ratings - Service areas calculations. Distribution system expansion: Planning – Load characteristics – Load forecasting – Design concepts – Optimal location of substation – Design of radial lines – Solution technique.

REFERENCES:

1. C.L. Wadhwa, "Electrical Power Systems", New Age International Publishers, Sixth Edition, 2014.
2. A.S. Pabla, "Electrical Power Distribution Systems", Tata McGraw Hill Books Company, Sixth Edition, 2011.
3. V. Kamaraju, "Electrical Power Distribution Systems", Tata McGraw Hill Books Company, Sixth Edition, 2009.
4. Anthony J. Pansini, "Electrical Distribution Engineering", CRC Press, 2005.
5. H Lee Willis, "Distributed Power Generation Planning and Evaluation", CRC Press, 2000.
6. James A Momoh, "Electric Power Distribution Automation Protection and Control" CRC Press, 2007.
7. James J. Burke, "Power distribution engineering: fundamentals and applications", CRC Press, 2004.

COURSE OUTCOMES:

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

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

Mapping with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1									2	3		1
CO2	3	2	1											1	2
CO3	2	2	1												2
CO4	2	2	2								1	1	1		1
CO5	3	2	1									1	3	1	

PSEEX0X	SOFT COMPUTING TECHNIQUES	L	T	P
		4	0	0

COURSE OBJECTIVES:

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

Introduction and Artificial Neural Networks

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

Associative Memory and Unsupervised Neural Networks

Auto associative and hetero associative memory in neural network - Discrete Hopfield network. Fixed weight competitive network – Self organizing network – Adaptive Resonance Theory- Identification and control of linear and nonlinear dynamic systems using Matlab-Neural Network toolbox.

Fuzzy Logic System

Introduction to Classical Sets and Fuzzy sets – Fuzzy set operation - approximate reasoning – extension principle - Fuzzy statements - Decomposition of compound rules. Fuzzification - Membership value assignments using intuition - Membership functions- Defuzzification - Fuzzy rule and knowledge bases - fuzzy logic controller - Implementation of fuzzy logic controller using Matlab fuzzy logic toolbox.

Genetic Algorithm

Optimization – Traditional optimization methods – Concept of Evolutionary Algorithm – Genetic Algorithm – encoding and decoding of variables – GA operators – fitness function – fitness scaling - procedures of GA - flow chart of GA. Implementation of GA to power system optimization problem.

Swarm Optimization

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

REFERENCES:

1. LawreneFaussett, "Fundamental of neural networks", Prentice Hall, 2004.
2. Rajasekaran and VijayalakshmiPai G.A, "Neural Networks, Fuzzy Logic and Genetic Algorithms – Synthesis and Applications", Prentice Hall, 2015.
3. Dorigo Marco Stützle Thomas, "Ant Colony Optimization", Prentice Hall India Learning Private Limited, 2004.
4. Russell C. Eberhart , Yuhui Shi and James Kennedy, "Swarm Intelligence", Morgan Kaufmann, 1st edition, 2001.
5. Jesse Russell, Ronald Cohn, "Artificial Bee Colony Algorithm", Book on Demand Ltd., 2012.

COURSE OUTCOMES:

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

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

Mapping with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3				3				2			1	3		
CO2	2	3	3	3							2		3		3
CO3	3	3		3					2				3		3
CO4			3		3						2		3		3
CO5			3		3								3		3

PSEEX0X	OPTIMIZATION TECHNIQUES	L	T	P
		4	0	0

COURSE OBJECTIVES:

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

Introduction to Optimization

Engineering applications – Classification of optimization problems – Classical optimization techniques – Single and multivariable optimization – multivariable optimization with and without constraints – Saddle point – Solution by the method of Lagrange multipliers – Kuhn tucker conditions.

Linear Programming

Applications – Standard form of LPP – definitions and Theorems – Solution of a system of Linear simultaneous equations – Pivotal reduction – Simplex algorithm – Revised simplex method.

Duality in linear programming – Dual simplex method – Decomposition principle - Transportation problem – Northwest corner rule – Least cost method.

Non Linear Programming

One dimensional minimization methods – unrestricted search – Exhaustive search – Interpolation methods – Quadratic and cubic interpolation methods.

Unconstrained optimization techniques – Direct search methods – Simplex method – Indirect search (descent) methods – Gradient of a function – Steepest Descent method-Constrained optimization techniques – Transformation techniques – penalty function methods or sequential unconstrained minimization techniques (SUMT) – Interior and exterior penalty function method - Extrapolation technique – Augmented Lagrange multiplier method – Checking the convergence of constrained optimization problems – Perturbing the design vector – Kuhn-Tucker conditions.

Geometric Programming and Integer Programming

Geometric programming - Polynomial – Unconstrained minimization problem – Constrained minimization problem – Primal and Dual programs – Geometric programming with mixed inequality constraints – Complementary geometric programming.

Integer linear programming – Mixed integer programming – Integer non linear programming – Sequential linear discrete programming.

Dynamic Programming

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

REFERENCES:

1. R. L. Rardin, "Optimization in Operation Research", Pearson Education Private Ltd., Second Edition, 2016.
2. S. S. Rao, "Engineering Optimization: Theory and Practice", John Wiley & Sons, Fourth Edition, 2009.
3. F. S. Hiller and G. J. Lieberman, "Introduction to Operations Research", Tata McGraw Hill, Ninth Edition, 2010.
4. C. B. Gupta, "Optimization Techniques in Operations Research", I. K. International Publishing House Private Ltd., Second Edition, 2012.
5. H. A. Taha, "Operations Research - An Introduction", Prentice Hall, Eighth Edition, 2008.
6. S. S. Rao, "Optimization: Theory and Applications", New Age International (P) Ltd., Third Edition, 2004.

COURSE OUTCOMES:

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

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

Mapping with Program Outcomes															
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3		2										2		
CO2	3	3											2		
CO3	3	3	2		1								2		
CO4	3	2	2		1								2		
CO5		2			1								2		

PSEEX0X	CLOUD COMPUTING	L	T	P
		4	0	0

COURSE OBJECTIVES:

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

An Overview

Cloud Computing- Definition-motivation-characteristics- Past, Present, and Future-Cloud Computing Methodologies-The Cloud Architecture-Cloud Deployment Techniques-Cloud Services-Cloud Applications-Issues with Cloud Computing-comparison between Cloud Computing and Grid Computing-Benefits, Limitations, and Concerns associated with Cloud Computing-prospects and implications

Cloud Services

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

Virtualization

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

Programming Models for Cloud Computing

Existing and Extended Programming Models for Cloud- BSP Model- Map Reduce Model- Map Reduce --Model- Cloud Haskell- Multi MLton- Erlang- SORCER: Object-Oriented Programming- Programming Models in Aneka- New Programming Models Proposed for Cloud- Orleans- BOOM and Bloom- Grid Batch- Simple API for grid applications

Applications and Prospects

Cloud Applications- Engineering Applications- Educational Applications- Personal Applications- Cloud Gaming- Cloud Prospects- Impact of the Cloud on IT Professionals and the IT Industry- Cloud Computing in Emerging Markets- Research Topics in Cloud Computing- The Future of the Clouds.

REFERENCES:

1. K. Chandrasekaran, “Essentials of Cloud Computing”, CRC press, 2015
2. RajkumarBuyya, James Broberg, Andrzej M. Goscinski, “Cloud Computing: Principles and Paradigms”, Wiley, 2011.
3. Dan C. Marinescu, “Cloud Computing: Theory and Practice, Morgan Kaufmann,2013.

4. San Murugesan, Irena Bojanova, “Encyclopedia of Cloud Computing”, Wiley-IEEE press, 2016.
5. Derrick Rountree, Ileana Castrillo,“The Basics of Cloud Computing: Understanding the fundamentals of Cloud Computing in Theory and Practice”, Syngress, 2013.

COURSE OUTCOMES:

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

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

Mapping with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3						2					1	2		
CO2	3							1	3				2		
CO3	3		2		3								2		
CO4			3		3				2			1	3		
CO5			3		3		2	1	3				3		

PSEEX0X	SCIENTIFIC RESEARCH AND TECHNICAL COMMUNICATION	L	T	P
		4	0	0

COURSE OBJECTIVES:

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

Scientific Research

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

Technical Communication

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

Listening and Speech Techniques

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

Technical Reports and Proposals

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

Technical Papers and Descriptions

Types of technical papers - Journal papers, Conference papers, Survey papers, Poster papers, Review papers- Research Paper- Characteristics- Components- Technical Description-Guidelines for Writing Good Descriptions- Writing Technical Descriptions- Ethical Issues in Writing- Moral and Social Responsibilities- Responsibilities to Coauthors- Citations and Plagiarism- Copyright Issues- Permissions for Tables and Figures- Introduction to LATEX

REFERENCES:

1. Meenakshi Raman, Sangeeta Sharma, “Technical Communication-Principles and Practice”, Oxford University Press, 2015
2. Kothari, C.R., "Research Methodology: Methods and Techniques". New Age International, 2014.
3. Alexander M. Novikov and Dmitry A. Novikov, “Research Methodology, From Philosophy of Science to Research Design”, CRC Press, 2013
4. Raymond Greenlaw, “Technical Writing, Presentational Skills, and Online Communication: Professional Tools and Insights”, IGI Global, 2012
5. Mike Markel, “Technical Communication” , Bedford St. Martin's, 2016

COURSE OUTCOMES:

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

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

Mapping with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1		3		3	1		1			3		
CO2	3	1	1		2	3	3	1		1			3		2
CO3	3	1	2	2	2	3	2	1					3	2	2
CO4	3	2	2	2	2	3	3	1		2			2	2	2
CO5	3	2	2	2	2	2	3	1		1			2	2	

PSEEX0X	INTERNET OF THINGS	L	T	P
		4	0	0

COURSE OBJECTIVES:

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

Introduction

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

IoT Services

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

IoT Protocols

Standardization of protocol for IoT – efforts – M2M and WSN protocols – SCADA and RFID protocols – issues with IoT standardization – unified data standards – protocols -IEEE 802.15.4 – BACNet protocol – modbus – KNX – Zigbee architecture – network layer– APS layer – security

Programming Frameworks, Cloud and Fog Computing

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

Security and Privacy in IoT

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

REFERENCES:

1. RajkumarBuyya, AmirVahidDastjerdi, “Internet of Things: Principles and Paradigms”, Morgan Kaufmann, 2016.
2. Honbo Zhou, “The Internet of Things in the Cloud: A Middleware Perspective”, CRC Press, 2012.
3. Dieter Uckelmann, Mark Harrison, Florian Michahelles, “Architecting the Internet of Things”, Springer, 2011.
4. Olivier Hersent, David Boswarthick, Omar Elloumi, “The Internet of Things – Key applications and Protocols”, Wiley, 2012

5. Hakima Chaouchi, "The Internet of Things- Connecting Objects to the Web", Wiley, 2010.

COURSE OUTCOMES:

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

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

Mapping with Program Outcomes

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

PSEEX0X	INTELLECTUAL PROPERTY RIGHTS	L	T	P
		4	0	0

COURSE OBJECTIVES:

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

Introduction to Intellectual property rights

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

Copyright

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

Patents and Designs

Definition- patentable and non-patentable inventions- Foundations of Patent Law- Patent Searches, Applications, and Post-IssuanceProceedings- Patent Ownership and Transfer- Patent Infringement- New Developments and International Patent Law- Patent System in India-Design-Need for registration of design-Essential requirements for registration of Design-Remedies against infringement-Design law in India

Trademark

Definition-Types-Functions- Trademark Selection and Searching- The Trademark Registration Process- Post registration – Maintenance and Transfer of Rights to Marks- Infringement- New Developments in Trademark Law- International Trademark Law-Trade Marks law of India-Trade Secrets law-Factors indetermination of trade secret status-remedies for Misappropriation

Intellectual Property Management

Definition-Need and importance- Overall management of IPRs - Generation of new inventions - Patent protection - Market watch - Management of non-registerable rights - Software - Other technical rights - Trade mark policy - IPR trading - Collaborations - Valuation - Encouraging innovation -Major IP Management Activities-5Cs model of managing IP

REFERENCES:

1. Deborah. E. Bouchoux, "Intellectual Property:The Law of Trademarks,Copyrights,Patents, andTrade Secrets", Cengage learning, 2013.
2. NeerajPandey and KhushdeepDhami, "Intellectual property rights", Prentice-Hall Inc., 2014.
3. N.S. Gopalakrishnan and T.G. Agitha, "Principles of Intellectual Property", Eastern Book Company, Lucknow, 2009.
4. Vivien Irish, "Intellectual Property Rights for Engineers", The Institution of Engineering and Technology, 2008.
5. S.R.A. Rosedar," Intellectual property rights", LexisNexis, 2016.

COURSE OUTCOMES:

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

1. Understand the concept of Intellectual property rights.
2. Familiarize with the copyright laws.
3. Acquire knowledge on Patenting and Design.
4. Learn about Trademark and Trade secrets law.
5. Focus on Intellectual Property Management.

Mapping with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	2	1	2	2	2	3		2			3	2	2
CO2	2	2	2	1	2	3	3	3		2			3	2	2
CO3	2	2	2	1	2	3	3	3		2			3	2	2
CO4	1	1	1	2	3	2	3	3		3			3	3	2
CO5	1	1	2	1	2	3	2	3		2			3	2	2

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