B.S.ABDUR RAHMAN
UNIVERSITY
B.S.ABDUR RAHMAN INSTITUTE OF SCIENCE & TECHNOLOGY
(Estd.u/s 3 of the UGC Act, 1956)

(FORMERLY B.S.ABDUR RAHMAN CRESCENT ENGINEERING COLLEGE)
Seethakathi Estate, G.S.T. Road, Vandalur, Chennai - 600 048.

REGULATIONS (2009), CURRICULUM AND SYLLABUS
FOR
M.TECH. (POWER SYSTEMS ENGINEERING)
(FOUR SEMESTERS / FULL TIME)

(Updated upto June 2012)

REGULATIONS 2009
FOR
M.TECH. POWER SYSTEMS ENGINEERING

REGULATIONS (2009) FOR
M.TECH. (POWER SYSTEMS ENGINEERING)
(FOUR SEMESTERS / FULL TIME)

1.0 PRELIMINARY DEFINITIONS AND NOMENCLATURE

In these Regulations, unless the context otherwise requires

i) **"Programme"** means Post Graduate Degree Programme (M.Tech./ MCA / M.Sc.)

ii) **"Course"** means a theory or practical subject that is normally studied in a semester, like Applied Mathematics, Structural Dynamics, Computer Aided Design, etc.

iii) **"University"** means B.S.Abdur Rahman University, Chennai, 600048.

iv) **"Institution"** unless otherwise specifically mentioned as an autonomous or off campus institution means B.S.Abdur Rahman University.

v) **"Academic Council"** means the Academic Council of the University.

vi) **'Dean (Academic Courses)'** means Dean (Academic Courses) of B.S.Abdur Rahman University.

vii) **'Dean (Students)'** means Dean(Students) of B.S.Abdur Rahman University.

viii) **"Controller of Examinations"** means the Controller of Examinations of B.S.Abdur Rahman University who is responsible for conduct of examinations and declaration of results.

2.0 PROGRAMMES OFFERED, MODE OF STUDY AND ADMISSION REQUIREMENTS

2.1 P.G. Programmes Offered

The various P.G. Programmes and their modes of study are as follows:

Degree	Mode of study
M.Tech.	Full Time
M.Tech.	Part Time – Day / Evening
M.C.A.	Full Time
M. Sc.	Full Time

2.2 MODES OF STUDY

2.2.1 Full-time

Candidates admitted under "Full-Time" shall be available in the institution during the complete working hours for curricular, co-curricular and extra-curricular activities assigned to them.

2.2.2 A full time student, who has completed all non-project courses desiring to do the Project work in part-time mode for valid reasons, shall apply to the Head of the Institution through the Head of the Department, if the student satisfies the clause 2.3.5 of this Regulations. Permission may be granted based on merits of the case. Such conversion is not permitted in the middle of a semester.

2.2.3 Part time - Day time

In this mode of study, the candidates are required to attend classes for the courses registered along with full time students.

2.2.4 Part time - Evening

In this mode of study, the candidates are required to attend only evening classes.

2.2.5 A part time student is not permitted to convert to the full time mode of study.

2.3. ADMISSION REQUIREMENTS

2.3.1 Candidates for admission to the first semester of the Master's Degree Programme shall be required to have passed an appropriate degree examination of this University as specified in Table 1 or any other examination of any University or authority accepted by the University as equivalent thereto.

2.3.2 Notwithstanding the qualifying examination the candidate might have passed, he/she shall have a minimum level of proficiency in the appropriate programme/courses as prescribed by the institution from time to time.

2.3.3 Eligibility conditions for admission such as class obtained, number of attempts in qualifying examination and physical fitness will be as prescribed by the Institution from time to time.

2.3.4 All part-time candidates should satisfy other conditions regarding experience, sponsorship etc., which may be prescribed by the institution from time to time.

2.3.5 A candidate eligible for admission to M.Tech. Part Time - Day Time programmeshall have his/her permanent place of work within a distance of 65km from the campus of the institution.

2.3.6 A candidate eligible for admission to M.B.A. Part Time - Evening programme shall have a working experience of 2 years at least at supervisory level. He/ she shall have his/her place of work within a distance of 65 km from the campus of the institution.

3.0 DURATION AND STRUCTURE OF THE P.G. PROGRAMME

3.1. The minimum and maximum period for completion of the P.G. Programmes are given below:

Programme	Min. No. of Semesters	Max. No. of Semesters
M.Tech. (Full Time)	4	8
M.Tech.(Part Time)	6	12
M.C.A. (Full Time)	6	12
M.Sc. (Full Time)	4	8

3.2 The P.G. programmes will consist of the following components as prescribed in the respective curriculum

i. Core courses

ii. Elective courses

iii. Project work / thesis / dissertation

iv. Laboratory Courses

v. Case studies

vi. Seminars

vii. Practical training

3.3 The curriculum and syllabi of all the P.G. programmes shall be approved by the Academic Council.

3.4 The number of credits to be earned for the successful completion of the programme shall be specified in the curriculum of the respective specialization of the P.G. programme.

3.5 Each academic semester shall normally comprise of 75 to 80 working days spread over sixteen weeks. End-semester examinations will follow immediately after these working days.

ELIGIBLE ENTRY QUALIFICATIONS FOR ADMISSION TO P.G. PROGRAMMES

Sl.No.	Name of the Department	P.G. Programmes offered	Qualifications for admission
01.	Civil Engineering	M.Tech. (Structural Engineering)	B.E / B.Tech. (Civil Engineering) / (Structural Engineering)
		M.Tech. (Construction Engineering and Project Management)	B.E. / B.Tech. (Civil Engineering) /(Structural Engineering)
02.	Mechanical Engineering	M.Tech. (CAD - CAM)	B.E. / B.Tech. (Mechanical / Auto /Manufacturing / Production / Industrial/Mechatronics / Metallurgy / Aerospace/Aeronautical / Material Science / Marine Engineering)
		M.Tech. (Manufacturing Engineering)	B.E. / B.Tech. (Mechanical / Auto / Manufacturing / Production / Industrial/Mechatronics / Metallurgy / Aerospace/Aeronautical / Material Science / Marine Engineering)
03.	Polymer Technology	M.Tech. (Polymer Technology)	B. E. / B. Tech. degree Mech./ Production / Polymer Science or Engg or Tech/Rubber Tech/ M.Sc(Polymer Sc./Chemistry Appl. Chemistry)
04.	Electrical and Electronics Engineering	M.Tech. (Power Systems Engg)	B.E/B.Tech (EEE/ECE/E&I/ I&C/ Electronics / Instrumentation)
		M.Tech. (Power Electronics & Drives)	B.E/B.Tech (EEE/ECE/E&I/ I&C/ Electronics/ Instrumentation)
05.	Electronics and Communication Engineering	M.Tech. (Communication Systems)	M.Tech (Power System Engg) B.E / B.Tech (EEE/ ECE / E&I / I&C / Electronics / Instrumentation)
		M.Tech. (VLSI and Embedded Systems)	B.E./ B.Tech. in ECE / Electronics / EIE
06.	ECE Department jointly with Physics Department	M.Tech. (Optoelectronics and Laser Technology)	B.E./B.Tech. (ECE / EEE / Electronics / EIE / ICE) M.Sc (Physics / Materials Science / Electronics / Photonics)
07.	Electronics and Instrumentation Engineering	M.Tech. (Electronics and Instrumentation Engineering)	B.E./B.Tech. (EIE/ICE/Electronics/ECE/EEE)
08.	Computer Science and Engineering	M.Tech. (Computer Science and Engineering)	B.E. /B.Tech. (CSE/IT/ECE/EEE/EIE/ICE/ Electronics / MCA)
		M.Tech. (Software Engineering)	B.E. / B.Tech. (CSE / IT) MCA
09	Information Technology	M.Tech. (Information Technology)	B.E /B.Tech. (IT/CSE/ECE/EEE/EIE/ICE/ Electronics) MCA
10	Computer Applications	M.C.A.	Any degree. Must have studied Mathematics / Statistics /Computer oriented subject.
		M.Tech. (Systems Engineering and Operations Research)	Any degree. Must have studied Mathematics / Statistics /Computer oriented subject.
11	Mathematics	M.Sc. (Actuarial Science)	B.Sc. (Mathematics) of B.Sc. (Applied Science)
12	Chemistry	M.Sc.(Chemistry)	B.Sc (Chemistry) of B.Sc. (Applied Science)

3.6 The curriculum of P.G. programmes shall be so designed that the minimum prescribed credits required for the award of the degree shall lie within the limits specified below:

Programme	Minimum prescribed credit range
M.Tech.	70 to 80
M.C.A	130 to 140
M.Sc	74 to 80

3.7 Credits will be assigned to the courses for all P.G. programmes as given below:

* One credit for one lecture period per week
* One credit for one tutorial period per week
* One credit each for seminar/practical session of two or three periods per week
* One credit for four weeks of practical training

3.8 The number of credits registered by a candidate in non-project semester and project semester should be within the range specified below:

P.G. Programme	**Non-project Semester**	**Project semester**
M.Tech. (Full Time)	15 to 23	12 to 20
M.Tech. (Part Time)	6 to 12	12 to 16
M.C.A. (Full Time)	12 to 25	12 to 20
M.Sc. (Full Time)	15 to 25	12 to 20

3.9 The electives from the curriculum are to be chosen with the approval of the Head of the Department.

3.10 A candidate may be permitted by the Head of the Department to choose electives offered from other P.G. Programmes either within a Department or from other Departments up to a maximum of three courses during the period of his/her study, provided the Heads of the Departments offering such courses also agree.

3.11 To help the students to take up special research areas in their project work and to enable the department to introduce courses in latest/emerging areas in the curriculum, "Special Electives" may be offered. A candidate may be permitted to register for a "Special Elective" up to a maximum of three credits during the period of his/her study, provided the syllabus of this course is recommended by the Head of the Department and approved by the Dean (AC) before the commencement of the semester, in which the special elective course is offered. Subsequently, such course shall be ratified by the Board of Studies and Academic Council.

3.12 The medium of instruction, examination, seminar and project/thesis/ dissertation reports will be English.

3.13 Practical training or industrial attachment, if specified in the curriculum shall be of not less than four weeks duration and shall be organized by the Head of the Department.

3.14 PROJECT WORK/THESIS/DISSERTATION

3.14.1 Project work / Thesis / Dissertation shall be carried out under the supervision of a qualified teacher in the concerned Department.

3.14.2 A candidate may however, in certain cases, be permitted to work on the project in an Industrial/Research Organization, on the recommendation of Head of the Department, with the approval of the Head of the Institution. In such cases, the project work shall be jointly supervised by a supervisor of the Department and an Engineer / Scientist from the organization and the student shall be instructed to meet the supervisor periodically and to attend the review committee meetings for evaluating the progress.

3.14.3 Project work / Thesis / Dissertation (Phase - II in the case of M.Tech.) shall be pursued for a minimum of 16 weeks during the final semester, following the preliminary work carried out in Phase-1 during the previous semester.

3.14.4 The Project Report/Thesis / Dissertation report / Drawings prepared according to approved guidelines and duly signed by the supervisor(s) and the Head of the Department shall be submitted to the Head of the Institution.

3.14.5 The deadline for submission of final Project Report / Thesis / Dissertation is within 30 calendar days from the last working day of the semester in which Project / Thesis / Dissertation is done.

3.14.6 If a candidate fails to submit the Project Report / Thesis / Dissertation on or before the specified deadline he / she is deemed to have not completed the Project Work / Thesis / dissertation and shall re-register the same in a subsequent semester.

3.14.7 A student who has acquired the minimum number of total credits prescribed in the Curriculum for the award of the Masters Degree will not be permitted to enroll for more courses to improve his/her cumulative grade point average (CGPA).

4.0 FACULTY ADVISER

To help the students in planning their courses of study and for getting general advice on academic programme, the concerned department will assign a certain number of students to a faculty member who will be called the Faculty Adviser.

5.0 CLASS COMMITTEE

5.1 Every class of the P.G. Programme will have a Class Committee, constituted by the Head of the Department as follows:

i. Teachers of all courses of the programme

ii. One senior faculty preferably not offering courses for the class, as chairperson.

iii. One or two students of the class, nominated by the Head of the Department.

iv. Faculty Advisers of the class - Ex-Officio Members

v. Professor in-charge of the P.G. Programme - Ex-Officio Member.

5.2 The Class Committee shall be constituted by the respective head of the department of the students.

5.3 The basic responsibilities of the Class Committee are to review periodically the progress of the classes, to discuss problems concerning curriculum and syllabi and the conduct of the classes. The type of assessment for the course will be decided by the teacher in consultation with the Class Committee and will be announced to the students at the beginning of the semester. Each Class Committee will communicate its recommendations to the Head of the Department and the Head of the Institution. The class committee, **without the student members,** will also be responsible for finalization of the semester results.

5.4 The Class Committee is required to meet at least thrice in a semester, once at the beginning of the semester, another time after the end-semester examination to finalise the grades, and once in between.

6.0 COURSE COMMITTEE

Each common theory course offered to more than one group of students shall have a "Course Committee" comprising all the teachers teaching the common course with one of them nominated as Course coordinator. The nomination of the Course coordinator shall be made by the Head of the Department / Head of the Institution depending upon whether all the teachers teaching the common course belong to a single department or to several departments. The Course Committee shall meet as often as possible and ensure uniform evaluation of the tests and arrive at a common scheme of evaluation for the tests. Wherever it is feasible, the Course Committee may also prepare a common question paper for the test(s).

7.0 REGISTRATION AND ENROLMENT

7.1 For the first semester every student has to register and enroll for the courses he/she intends to undergo on a specified day notified to the student. The concerned Faculty Adviser will be present and guide the students in the registration/enrolment process.

7.2 For the subsequent semesters registration for the courses will be done by the student during a specified week before the end-semester examination of the previous semester. The curriculum gives details of the core and elective courses, project and seminar to be taken in different semester with the number of credits. The student should consult his/her Faculty Adviser for the choice of courses. The Registration form is filled in and signed by the student and the Faculty Adviser.

7.3 Late registration will be permitted with a prescribed fine up to two weeks from the last date specified for registration.

7.4 From the second semester onwards all students shall pay the prescribed fees and enroll on a specified day at the beginning of a semester.

A student will become eligible for enrolment only if he/she satisfies clause 9 and in addition he/she is not debarred from enrolment by a disciplinary action of the Institution. At the time of enrolment a student can drop a course registered earlier and also substitute it by another course for valid reasons with the consent of the Faculty Adviser. Late enrolment will be permitted on payment of a prescribed fine up to two weeks from the date of commencement of the semester.

7.5 Withdrawal from a course registered is permitted up to one week from the date of the completion of the first assessment test.

7.6 Change of a course within a period of 15 days from the commencement of the course, with the approval of Dean (AC), on the recommendation of the HOD, is permitted.

7.6.1 Courses withdrawn will have to be taken when they are offered next if they belong to the list of core courses.

7.7 SUMMER TERM COURSES

7.7.1 Summer term courses may be offered by a department on the recommendation by the Departmental Consultative Committee and approved by the Head of the Institution. No student should register for more than three courses during a summer term.

7.7.2 Summer term courses will be announced by the Head of the Institution at the end of the even semester before the commencement of the end semester examinations. A student will have to register within the time stipulated in the announcement. A student has to pay the fees as stipulated in the announcement.

7.7.3 Fast-track summer courses of 30 periods for 3 credit courses and 40 periods for 4 credit courses will be offered for students with I grades. They may also opt to redo such courses during regular semesters with slotted time-tables. Students with U grades will have the option either to write semester end arrears exam or to redo the courses during summer / regular semesters with slotted time-table, if they wish to improve their continuous assessment marks also.

The assessment procedure in a summer term course will also be similar to the procedure for a regular semester course.

7.7.4 Withdrawal from a summer term course is not permitted. No substitute examination will be held for the summer term courses.

8.0 TEMPORARY WITHDRAWAL FROM THE PROGRAMME

A student may be permitted by the Head of the Institution to temporarily withdraw from the programme up to a maximum of two semesters for reasons of ill health or other valid grounds. However the total duration for completion of the programme shall not exceed the prescribed number of semesters (vide clause 3.1).

9.0 MINIMUM REQUIREMENTS TO REGISTER FOR PROJECT / THESIS / DISSERTATION

9.1 A candidate is permitted to register for project semester, if he/she has earned the minimum number of credits specified below:

Programme	Minimum No. of credits to be earned to enrol for project semester
M.Tech. (Full time)	18 (III semester)
M.Tech. (Part-time)	18 (V semester)
M.C.A. (Full time)	45 (VI semester)
M.Sc. (Full-time)	28 (IV semester)

9.2 **M.Tech.:** If the candidate has not earned minimum number of credits specified, he/she has to earn the required credits (at least to the extent of minimum credit specified in clause 9.1) and then register for the project semester.

9.3 **M.C.A.:** If the candidate has not earned the required minimum number of credits specified he/she has to earn the required credits (at least to the extent of minimum credits specified in clause 9.1) and then register for the project work in subsequent semesters.

10.0 DISCIPLINE

10.1 Every candidate is required to observe discipline and decorous behaviour both inside and outside the campus and not to indulge in any activity, which will tend to bring down the prestige of the institution.

10.2 Any act of indiscipline of a candidate reported to the Head of the Institution will be referred to a Discipline and Welfare Committee for taking appropriate action.

10.3 Every candidate should have been certified by the HOD that his / her conduct and discipline have been satisfactory.

11.0 ATTENDANCE

11.1 Attendance rules for all Full Time Programme and Part time - day Time Programmes are given in the following sub-clauses.

11.2 A student **shall earn 100% attendance** in the contact periods of every course, subject to a **a maximum relaxation of 25%** for genuine reasons like on medical grounds , representing the University in approved events etc., to become eligible to appear for the end-semester examination in that course, failing which the student shall be awarded "I" grade in that course. If the course is a core course, the candidate should register for and repeat the course when it is offered next.

12.0 ASSESSMENTS AND EXAMINATIONS

12.1 The following rule shall apply to the full-time and part-time P.G. programmes (M.Tech./ M.C.A. / M.Sc.)

For lecture-based courses, normally a minimum of two assessments will be made during the semester. The assessments may be combination of tests and assignments. The assessment procedure as decided at the Class Committee will be announced to the students right at the beginning of the semester by the teacher and informed to Dean(AC)

12.2 There shall be one **examination** of three hours duration, at the end of the semester, in each lecture based course.

12.3 The evaluation of the Project work will be based on the project report and a Viva-Voce Examination by a team consisting of the supervisor concerned, an Internal Examiner and External Examiner to be appointed by the Controller of Examinations.

12.4 At the end of practical training or industrial attachment, the candidate shall submit a certificate from the organization where he/she has undergone training and also a brief report. The evaluation will be made based on this report and a Viva-Voce Examination, conducted internally by a Departmental Committee constituted by the Head of the Department.

13.0 WEIGHTAGES

13.1 The following shall be the weightages for different courses:

i) Lecture based course

Two sessional assessments	-	50%
End-semester examination	-	50%

ii) Laboratory based courses

Laboratory work assessment	-	75%
End-semester examination	-	25%

iii) Project work

Periodic reviews	-	50%
Evaluation of Project Report by External Examiner	-	20%
Viva-Voce Examination	-	30%

13.2 The markings for all tests, tutorial assignments (if any), laboratory work and examinations will be on absolute basis. The final percentage of marks is calculated in each course as per weightages given in clause 13.1.

14.0 SUBSTITUTE EXAMINATION

14.1 A student who has missed for genuine reasons any one of the three assessments including end-semester examination of a course may be permitted to write a substitute examination. However, permissions to take up a substitute examination will be given under exceptional circumstances, such as accident or admissions to a hospital due to illness, etc.,

14.2 A student who misses any assessment in a course shall apply in a prescribed form to the Dean(AC) through the Head of the department within a week from the date of missed assessment. However the substitute tests and examination for a course will be conducted within two weeks after the last day of the end-semester examinations.

15.0 COURSEWISE GRADING OF STUDENTS AND LETTER GRADES:

15.1 Based on the semester performance, each student is awarded a final letter grade at the end of the semester in each course. The letter grades and the corresponding grade points are as follows, but grading has to be relative grading

Letter grade	Grade points
S	10
A	9
B	8
C	7
D	6
E	5
U	0
I	-
W	-

Flexible range grading system will be adopted

"W" denotes withdrawal from the course.

"I" denotes inadequate attendance and hence prevention from End Semester examination.

"U" denotes unsuccessful performance in a course.

15.2 A student is considered to have completed a course successfully and earned the credits if he / she secure five grade points or higher. A letter grade U in any course implies unsuccessful performance in that course. A course successfully completed cannot be repeated for any reason.

16.0 METHOD OF AWARDING LETTER GRADE:

16.1 A final meeting of the Class Committee without the student member(s) will be convened within ten days after the last day of the semester end examination. The letter grades to be awarded to the students for different courses will be finalized at the meeting.

16.2 Three copies of the results sheets for each course, containing the final grade and three copies with the absolute marks and the final grade should be submitted by the teacher to the concerned Class Committee Chairman. After finalisation of the grades at the class committee meeting the Chairman will forward two copies of each to the Controller of Examinations and the other copies to the Head of the Department in which course is offered.

17.0 DECLARATION OF RESULTS:

17.1 After finalisation by the Class Committee as per clause 16.1 the Letter Grades awarded to the students in the each course shall be announced on the departmental notice board after duly approved by the Controller of Examinations. In case any student feels aggrieved, he/she can apply for revaluation after paying the prescribed fee for the purpose, within two weeks from the commencement of the semester immediately following the announcement of results. A committee will be constituted by the Controller of Examinations comprising the Chairperson of the concerned Class Committee (Convener), the teacher concerned and another teacher of the department who is knowledgeable in the concerned course. If the Committee finds that the case is genuine, it may jointly revalue the answer script and forward the revised mark to the Controller of Examinations with full justification for the revision if any.

17.2 The **"U"** grade once awarded stays in the grade sheet of the students and is not deleted when he/she completes the course successfully later. The grade acquired by the student later will be indicated in the grade sheet of the appropriate semester.

18.0 COURSE REPETITION AND ARREARS EXAMINATION

18.1 A student should register to re-do a core course wherein "I" or "W" grade is awarded. If the student is awarded "I", or "W" grade in an elective course either the same elective course may be repeated or a new elective course may be taken.

18.2 A student who is awarded "U" grade in a course shall write the end-semester examination as arrear examination , at the end of the next semester, along with the regular examinations of next semester courses. **The marks earned earlier in the continuous assessment tests for the course, will be used for grading along with the marks earned in the end-semester arrear examination for the course.**

19.0 GRADE SHEET

19.1 The grade sheet issued at the end of the semester to each student will contain the following:

(i) the credits for each course registered for that semester.

(ii) the performance in each course by the letter grade obtained.

(iii) the total credits earned in that semester.

(iv) the Grade Point Average (GPA) of all the courses registered for that semester and the Cumulative Grade Point Average (CGPA) of all the courses taken up to that semester.

19.2 The GPA will be calculated according to the formula

$$GPA = \frac{\sum_i (Ci)(GPi)}{\sum_i Ci}$$

where C_i is the number of credits assigned for i^{th} course
GP_i - Grade point obtained in the i^{th} course
For the cumulative grade point average (CGPA) a similar formula is used except that the sum is over all the courses taken in all the semesters completed up to the point in time.

I and W grades will be excluded for GPA calculations.

U, I and W grades will be excluded for CGPA calculations.

19.3 Classification of the award of degree will be as follows:

CGPA	Classification
8.50 and above, having completed in first appearance in all courses	First class with Distinction
6.50 and above, having completed within a period of 2 semesters beyond the programme period.	First Class
All others	Second Class

However, to be eligible for First Class with Distinction, a candidate should not have obtained U or I grade in any course during his/her study and should have completed the P.G. Programme within a minimum period covered by the minimum duration (clause 3.1) plus authorized break of study, if any (clause 8). To be eligible for First Class, a candidate should have passed the examination in all courses within the specified minimum number. of semesters reckoned from his/her commencement of study plus two semesters. For this purpose, the authorized break of study will not be counted. The candidates who do not satisfy the above two conditions will be classified as second class. For the purpose of classification, the CGPA will be rounded to first decimal place. For the purpose of comparison of performance of candidates and ranking, CGPA will be considered up to three decimal places.

20 ELIGIBILITY FOR THE AWARD OF THE MASTERS DEGREE

20.1 A student shall be declared to be eligible for the award of the Masters Degree, if he/she has:

i) registered for and undergone all the core courses and completed the Project Work,

ii) successfully acquired the required credits as specified in the Curriculum corresponding to his/her programme within the stipulated time,

iii) successfully completed the field visit/industrial training, if any, as prescribed in the curriculum.

iv) has no dues to the Institution, Hostels and Library.

v) no disciplinary action is pending against him/her

20.2 The award of the degree must be approved by the University.

21.0 POWER TO MODIFY:

Notwithstanding all that have been stated above, the Academic Council has the right to modify any of the above regulations from time to time.

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CURRICULUM
FOR
M.Tech. POWER SYSTEMS ENGINEERING

M.TECH. (POWER SYSTEMS ENGINEERING)
(FOUR SEMESTERS / FULL TIME)

PROGRAMME OBJECTIVES:

- To develop competent and skilled power system engineers to meet the national and international industrial requirements.
- To meet the day to day challenges faced by the power sector, due to deregulation and to equip the students in power system software applications
- To meet the challenges of today's clean energy sector and to contribute to the environmental social concerns.
- To train the students to realistic industrial environment, meeting the modern engineering practices.

CURRICULUM

SEMESTER I

Sl. No	Subject Code	Subject	L	T	P	C	TC
Theory							
1	MA 615	Applied Mathematics for Electrical Engineers	3	1	0	4	
2	EE 601	Power System Analysis	3	1	0	4	
3	EE 602	Power System Protection	3	0	0	3	
4	EE 603	Electrical Transients in Power Systems	3	0	0	3	
5	EE 604	Systems Theory	3	0	0	3	
6		Elective I	3	0	0	3	
PRACTICAL							
7	EE 605	Power System Simulation Laboratory I	0	0	3	2	**22**

SEMESTER II

Sl. No	Subject Code	Subject	L	T	P	C	TC
Theory							
1	EE 606	Power System Operation and Control	3	0	0	3	
2	EE 607	Power System Dynamics	3	0	0	3	
3	EE 608	Flexible AC Transmission systems	3	0	0	3	
4	EE 609	Restructured Power Systems	3	0	0	3	
5		Elective II	3	0	0	3	
6		Elective III	3	0	0	3	
PRACTICAL							
7	EE 610	Power System Simulation Laboratory II	0	0	3	2	**20**

SEMESTER III

Sl. No	Subject Code	Subject	L	T	P	C	TC
Theory							
1		Elective IV	3	0	0	3	
2		Elective V	3	0	0	3	
3		Elective VI	3	0	0	3	
PRACTICAL							
4	EE 701	Project Work (Phase -I)	0	0	12	*	**9**

SEMESTER IV

Sl. No	Subject Code	Subject	L	T	P	C	TC
PRACTICAL							
1	EE 701	Project work (Phase -II)	0	0	35	24*	**24***

TOTAL CREDITS 75

Note: * Credits for Project work (Phase-I) of third semester will be accounted along with Project work (Phase-II) of fourth semester

LIST OF ELECTIVES

Course Code	Course Title	L	T	P	C
EEY 001	Electro Magnetic Field Computation and Modelling	3	0	0	3
EEY 002	Analysis of Electrical Machines	3	0	0	3
EEY 003	EHV Power Transmission	3	0	0	3
EEY 004	Special electrical Machines	3	0	0	3
EEY 005	Power Quality	3	0	0	3
EEY 006	Power system Planning and Reliability	3	0	0	3
EEY 007	Advanced Digital Signal Processing	3	0	0	3
EEY 008	Control System Design	3	0	0	3
EEY 009	High Voltage Switch Gear	3	0	0	3
EEY 010	Optimal Control and Filtering	3	0	0	3
EEY 011	Advanced Power System Dynamics	3	0	0	3
EEY 012	System Identification and Adaptive Control	3	0	0	3
EEY 013	Industrial Power System Analysis and Design	3	0	0	3
EEY 014	High Voltage Direct Current Transmission	3	0	0	3
EEY 015	Wind energy Conversion Systems	3	0	0	3
EEY 016	Power Electronics for Renewable Energy Systems	3	0	0	3
EEY 017	Applications of MEMS Technology	3	0	0	3
EEY 018	Outdoor Insulators	3	0	0	3
EEY 019	Power Distribution systems	3	0	0	3
EEY 020	Smart Power Grid	3	0	0	3
EEY 021	High voltage Pulse Generation, Measurement and Testing for Life Sciences	3	0	0	3
EEY 041	Automotive Infotainment Systems	3	0	0	3
EE 624	Analysis of Inverters	3	0	0	3
CSY 098	Soft Computing Techniques	3	0	0	3
MEY 012	Research Methodology	3	0	0	3

SYLLABUS
FOR
M.Tech. POWER SYSTEMS ENGINEERING

SEMESTER - I

MA 615 APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERS

L	T	P	C
3	1	0	4

OBJECTIVE:

The aim of this course is to acquire the knowledge and applications of norm matrix, LPP and its applications, applications of calculus of variations, and to acquire the electrical application knowledge in random process and queuing theory.

1. ADVANCED MATRIX THEORY: 9

Eigen-values using QR transformations - Generalized eigen vectors - Canonical forms - Singular value decomposition and applications - Pseudo inverse - Least square approximations.

2. LINEAR PROGRAMMING 9

Formulation - Graphical Solution - Simplex Method - Two Phase Method - Transportation and Assignment Problems.

3. ONE DIMENSIONAL RANDOM VARIABLES 9

Random variables - Probability function - moments - moment generating functions and their properties - Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions - Function of a Random Variable.

4. QUEUEING MODELS 9

Poisson Process - Markovian queues - Single and Multi Server Models - Little's formula - Machine Interference Model - Steady State analysis - Self Service queue.

5. COMPUTATIONAL METHODS IN ENGINEERING 9

Boundary value problems for ODE - Finite difference methods - Numerical solution of PDE - Solution of Laplace and Poisson equations - Liebmann's iteration process - Solution of heat conduction equation by Schmidt explicit formula and Crank-Nicolson implicit scheme - Solution of wave equation.

L= 45 T=15 TOTAL = 60

REFERENCES:

1. Bronson, R., Matrix Operation, Schaum's outline series, McGraw Hill, New York, (1989).
2. Taha, H. A., Operations Research: An Introduction, Seventh Edition, Pearson Education Edition, Asia, New Delhi (2002).
3. R. E. Walpole, R. H. Myers, S. L. Myers, and K. Ye, Probability and Statistics for Engineers & Scientists, Asia, 8th Edition, (2007).
4. Donald Gross and Carl M. Harris, Fundamentals of Queuing theory, 2nd edition, John Wiley and Sons, New York (1985).
5. Grewal, B.S., Numerical methods in Engineering and Science, 7th edition, Khanna Publishers, 200

EE 601 POWER SYSTEM ANALYSIS

L	T	P	C
3	1	0	4

OBJECTIVE:

To provide the student the knowledge and computational skills required to model and analyze large-scale power system under normal and abnormal operating conditions using efficient numerical techniques suitable for computer application which are required for planning and operation of power system.

1. SOLUTION TECHNIQUE 9

Sparse Matrix techniques for large scale power systems: Optimal ordering schemes for preserving sparsity. Flexible packed storage scheme for storing matrix as compact arrays - Factorization by Bifactorization and Gauss elimination methods; Repeat solution using Left and Right factors and L and U matrices.

2. POWER FLOW ANALYSIS 9

Power flow equation in real and polar forms; Review of Newton's method for solution; Adjustment of P-V buses; Review of Fast Decoupled Power Flow method; Sensitivity factors for P-V bus adjustment; Net Interchange power control in Multi-area power flow analysis: ATC, Assessment of Available Transfer Capability (ATC) using Repeated Power Flow method; Continuation Power Flow method.

3. OPTIMAL POWER FLOW 9

Problem statement; Solution of Optimal Power Flow (OPF) - The gradient method, Newton's method, Linear Sensitivity Analysis; LP methods - With real power variables only - LP method with AC power flow variables and detailed cost functions; Security constrained Optimal Power Flow; Interior point algorithm; Bus Incremental costs.

4. SHORT CIRCUIT ANALYSIS 9

Fault calculations using sequence networks for different types of faults. Bus impedance matrix (ZBUS) construction using Building Algorithm for lines with mutual coupling; Simple numerical problems. Computer method for fault analysis using ZBUS and sequence components. Derivation of equations for bus voltages, fault current and line currents, both in sequence and phase domain using Thevenin's equivalent and ZBUS matrix for different faults.

5. TRANSIENT STABILITY ANALYSIS 9

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

L= 45 T=15 Total = 60

REFERENCES:

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

EE 602 POWER SYSTEM PROTECTION

L	T	P	C
3	0	0	3

OBJECTIVE:

A protection scheme for Power System is designed to continuously monitor the Power System to ensure maximum continuity of Electrical Supply, with minimum damage to Life, Equipment and Property. Hence, the course on Power System Protection aims at the following

- To understand the Fault Characteristics of individual Power System elements
- Knowledgeable about the tripping characteristics of various protective relays and matching them
- The various schemes of protection employed in Generator and Transformer protection
- Significance of Over Current Protective Schemes
- The relays used for protecting of Transmission lines, bus bars, etc. including Electro Mechanical and Numerical Relays

1. EQUIPMENT PROTECTION 9

Types of transformers - Phasor diagram for a three - Phase transformer-Equivalent circuit of transformer - Types of faults in transformers- Over - current protection Percentage Differential Protection of Transformers - Inrush phenomenon-High resistance Ground Faults in Transformers - Inter-turn faults in transformers - Incipient faults in transformers - Phenomenon of over-fluxing in transformers - Transformer protection application chart .Electrical circuit of the generator -Various faults and abnormal operating conditions-rotor fault -Abnormal operating conditions; numerical examples for typical transformer and generator protection schemes

2. OVER CURRENT PROTECTION 9

Time - Current characteristics-Current setting - Time setting-Over current protective schemes - Reverse power or directional relay - Protection of parallel feeders - Protection of ring feeders - Earth fault and phase fault protection - Combined Earth fault and phase fault protection scheme - Phase fault protective scheme directional earth fault relay - Static over current relays; numerical example for a radial feeder

3. DISTANCE AND CARRIER PROTECTION OF TRANSMISSION LINES 9

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

4. BUSBAR PROTECTION 9

Introduction - Differential protection of busbars-external and internal fault - Actual behaviors of a protective CT - Circuit model of a saturated CT - External fault with one CT saturation :need for high impedance - Minimum internal fault that can be detected by the high - Stability ratio of high impedance busbar differential scheme - Supervisory relay-protection of three - Phase busbars-Numerical examples on design of high impedance busbar differential scheme.

5. NUMERICAL PROTECTION 9

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

TOTAL: 45 hrs

REFERENCES:

1. Y.G. Paithankar and S.R Bhide, "Fundamentals of Power System Protection", Prentice-Hall of India, 2003
2. P.Kundur, "Power System Stability and Control", McGraw-Hill, 1993.
3. Badri Ram and D.N. Vishwakarma, "Power System Protection and Switchgear", Tata McGraw- Hill Publishing Company, 2002.

EE 603 ELECTRICAL TRANSIENTS IN POWER SYSTEMS **L T P C**
3 0 0 3

OBJECTIVE:

To understand generation of switching and lightning transients, their propagation, reflection and refraction on the grid and their impact on grid equipment.

1. TRAVELLING WAVES ON TRANSMISSION LINE 9

Lumped and Distributed Parameters - Wave Equation - Reflection, Refraction, Behavior of Travelling waves at the line terminations - Lattice Diagrams - Attenuation and Distortion - Multi-conductor system and Velocity wave.

2. LINE CONSTANTS FOR OVERHEAD LINES 9

Introduction; Series impedance and shunt capacitance matrices for physical conductors including Carson's correction and skin effect; Elimination of ground wires and bundling-equivalent phase conductors; case studies; Symmetrical Components for O.H lines-transposition schemes for S.C and D.C. lines; Karrenbauer's and ?-?-0 transformation; independent modes on untransposed lines

3. COMPUTATION OF POWER SYSTEM TRANSIENTS 9

Principle of digital computation - Solution method in EMTP, Modal analysis, Z transforms, Computation using EMTP - EMTP modelling capabilities-Typical case studies

4. LIGHTNING, SWITCHING AND TEMPORARY OVERVOLTAGES 9

Lightning: Interaction between lightning and power system - Factors contributing to line design - Switching: Short line or kilometric fault - Energizing transients - closing and re-closing of lines - line dropping, load rejection - Voltage induced by fault - Very Fast Transient Overvoltage (VFTO)

5. INSULATION CO-ORDINATION 9

Principle of insulation co-ordination in Air Insulated substation (AIS) and Gas Insulated Substation (GIS), insulation level, statistical approach, co-ordination between insulation and protection level -overvoltage protective devices - lightning arresters, substation earthing.

TOTAL: 45 hrs

REFERENCES:

1. Pritindra Chowdhari, "Electromagnetic transients in Power System", John Wiley and Sons Inc., 1996.
2. Allan Greenwood, "Electrical Transients in Power System", Wiley & Sons Inc. New York, 1991.
3. H.W. Dommel, EMTP Theory Book, Microtran Power System Analysis Corporation, Vancouver, B.C, 1992
4. H.W. Dommel, Notes for E.E. 553, 1978
5. Klaus Ragaller, "Surges in High Voltage Networks", Plenum Press, New York, 1980.
6. IEEE Guide for safety in AC substation grounding IEEE Standard 80-2000.
7. Working Group 33/13-09 (1988), 'Very fast transient phenomena associated with Gas Insulated System', CIGRE, 33-13, pp. 1-20.

EE 604 **SYSTEMS THEORY** **L T P C**
3 0 0 3

OBJECTIVE:

The objective of this course is to introduce the concept of state variable representation of physical systems. Various state models and solutions of state equations are discussed. Role of Eigenvalues and Eigenvectors are emphasized. Controllability, observability, stabilisability and Detectability are introduced. Stability of linear and non linear systems are evaluated. The modal control of SISO and MIMO systems are also covered. Pole placement techniques of state feedback are also dealt with. An overview of full order and reduced order observer is discussed.

1. STATE VARIABLE REPRESENTATION 9

Introduction-Concept of State-State equation for Dynamic Systems-Time invariance and linearity-Nonuniqueness of state model-State Diagrams-Physical System and State Assignment.

2. SOLUTION OF STATE EQUATION 9

Existence and uniqueness of solutions to Continuous-time state equations-Solution of Nonlinear and Linear Time Varying State equations-Evaluation of matrix exponential-System modes-Role of Eigenvalues and Eigenvectors.

3. CONTROLLABILITY AND OBSERVABILITY 9

Controllability and Observability-Stabilizability and Detectability-Test for Continuous time Systems- Time varying and Time invariant case-Output Controllability-Reducibility-System Realizations.

4. STABILITY 9

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 Continuous-Time Autonomous Systems-Finding Lyapunov Functions for Nonlinear Continuous Time Autonomous Systems-Krasovskii and Variable-Gradient Method.

5. MODAL CONTROL 9

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.

TOTAL: 45 hrs

REFERENCES:

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

EE 605 POWER SYSTEM SIMULATION LABORATORY-I

L	T	P	C
0	0	3	2

OBJECTIVE:

1. To study and develop programs for steady state analysis of Power systems using Newton-Raphson method Fast decoupled method.
2. To study and develop programs for transient stability analysis of power systems.
3. To study and analyse electromagnetic transients in power systems.

LIST OF EXPERIMENTS

1. Development of Load flow analysis program by Newton-Raphson method using MAT LAB
2. Development of Load flow analysis program by FDPF method using MATLAB.
3. Development of Transient stability program for single machine-infinite bus system using classical machine model using MATLAB.
4. Transient stability analysis of multimachine power system using EUROSTAG.
5. Contingency analysis: Calculation of Generator shift factors and line outage distribution factors using MATLAB.
6. Economic dispatch using lambda-iteration method using C language.
7. Economic Dispatch with line flow constraints using MATLAB.
8. Unit commitment: Priority-list schemes and dynamic programming using MATLAB.
9. Analysis of switching surge using EMTP: Energisation of a long distributed-parameter line.
10. Simulation of Transient overvoltages using PSCAD.

SEMESTER - II

EE 606 POWER SYSTEM OPERATION AND CONTROL

L	T	P	C
3	0	0	3

OBJECTIVE:

1. To get an overview of system operation and control
2. To become familiar with the preparatory work necessary for meeting the next day's operation such as load forecasting, unit commitment and generation scheduling.
3. To review the basics of AGC and also study about the security of power systems.

1. LOAD FORECASTING 9

Introduction - Estimation of Average and trend terms - Estimation of periodic components - Estimation of Stochastic components: Time series approach - Auto- Regressive Model, Auto-Regressive Moving - Average Models - Kalman Filtering Approach - On-line techniques for non stationary load prediction.

2. UNIT COMMITMENT 9

Constraints in unit commitment - Spinning reserve - Thermal unit constraints - Other constraints - Solution using Priority List method, Dynamic programming method - Forward DP approach Lagrangian relaxation method - adjusting.

3. GENERATION SCHEDULING 9

The Economic dispatch problem - Thermal system dispatching with network losses considered - The Lambda - iteration method - Gradient method of economic dispatch - Economic dispatch with Piecewise Linear cost functions - Transmission system effects - A two generator system - coordination equations - Incremental losses and penalty factors-Hydro Thermal Scheduling using DP.

4. CONTROL OF POWER SYSTEMS 9

Review of AGC and reactive power control -System operating states by security control functions - Monitoring, evaluation of system state by contingency analysis - Corrective controls (Preventive, emergency and restorative) - Energy control centre - SCADA system - Functions - monitoring , Data acquisition and controls - EMS system.

5. STATE ESTIMATION 9

Maximum likelihood Weighted Least Squares Estimation: - Concepts - Matrix formulation - Example for Weighted Least Squares state estimation ; State estimation of an AC network: development of method - Typical results of state estimation on an AC network - State Estimation by Orthogonal Decomposition algorithm - Introduction to Advanced topics : Detection and Identification of Bad Measurements , Estimation of Quantities Not Being Measured , Network Observability and Pseudo - measurements - Application of Power Systems State Estimation.

TOTAL: 45 hrs

REFERENCES:

1. O.I.Elgerd, "Electric Energy System Theory - an Introduction", - Tata McGraw Hill, New Delhi - 2002.
2. P.Kundur; "Power System Stability and Control", EPRI Publications, California, 1994.
3. Allen J.Wood and Bruce.F.Wollenberg, "Power Generation Operation and Control', John Wiley & Sons, New York, 1996.
4. A.K.Mahalanabis, D.P.Kothari. and S.I.Ahson., "Computer Aided Power System Analysis and Control", Tata McGraw Hill publishing Ltd , 1984.

EE 607 POWER SYSTEM DYNAMICS

L	T	P	C
3	0	0	3

OBJECTIVE:

To model and analyse the dynamics of power system with its synchronous machines, turbines and various controllers when subjected to small signal and large signal disturbances and to design the system with enhanced stability.

1. SYNCHRONOUS MACHINE MODELLING 9

Schematic Diagram, Physical Description: armature and field structure, machines with multiple pole pairs, mmf waveforms, direct and quadrature axes, Mathematical Description of a Synchronous Machine: Basic equations of a synchronous machine: stator circuit equations, stator self, stator mutual and stator to rotor mutual inductances, dq0 Transformation: flux linkage and voltage equations for stator and rotor in dq0 coordinates, electrical power and torque, physical interpretation of dq0 transformation, Per Unit Representations: Lad-reciprocal per unit system and that from power-invariant form of Park's transformation; Equivalent Circuits for direct and quadrature axes, Steady-state Analysis: Voltage, current and flux-linkage relationships, Phasor representation, Rotor angle, Steady-state equivalent circuit, Computation of steady-state values, Equations of Motion: Swing Equation, calculation of inertia constant, Representation in system studies, Synchronous Machine Representation in Stability Studies: Simplifications for large-scale studies : Neglect of stator terms and speed variations, Simplified model with amortisseurs neglected: two-axis model with amortisseur windings neglected, classical model.

2. MODELLING OF EXCITATION AND SPEED GOVERNING SYSTEMS 9

Excitation System Requirements; Elements of an Excitation System; Types of Excitation System;Control and protective functions;IEEE (1992) block diagram for simulation of excitation systems. Turbine and Governing System Modelling: Functional Block Diagram of Power Generation and Control, Schematic of a hydroelectric plant, classical transfer function of a hydraulic turbine (no derivation), special characteristic of hydraulic turbine, electrical analogue of hydraulic turbine, Governor for Hydraulic Turbine: Requirement for a transient droop, Block diagram of governor with transient droop compensation, Steam turbine modelling: Single reheat tandem compounded type only and IEEE block diagram for dynamic simulation; generic speed-governing system model for normal speed/load control function.

3. SMALL-SIGNAL STABILITY ANALYSIS WITHOUT CONTROLLERS 9

Classification of Stability, Basic Concepts and Definitions: Rotor angle stability, The Stability Phenomena. Fundamental Concepts of Stability of Dynamic Systems: State-space representation, stability of dynamic system, Linearization, Eigen properties of the state matrix: Eigen values and eigenvectors, modal matrices, Eigen value and stability, mode shape and participation factor. Single-Machine Infinite Bus (SMIB) Configuration: Classical Machine Model stability analysis with numerical example, Effects of Field Circuit Dynamics: synchronous machine, network and linearised system equations, block diagram representation with K-constants; expression for K-constants (no derivation), effect of field flux variation on system stability: analysis with numerical example.

4. SMALL-SIGNAL STABILITY ANALYSIS WITH CONTROLLERS 9

Effects Of Excitation System: Equations with definitions of appropriate K-constants and simple thyristor excitation system and AVR, block diagram with the excitation system, analysis of effect of AVR on synchronizing and damping components using a numerical example, Power System Stabiliser: Block diagram with AVR and PSS, Illustration of principle of PSS application with numerical example, Block diagram of PSS with description, system state matrix including PSS, analysis of stability with numerical a example. Multi-Machine Configuration: Equations in a common reference frame, equations in individual machine rotor coordinates, illustration of formation of system state matrix for a two-machine system with classical models for synchronous machines, illustration of stability analysis using a numerical example. Principle behind small-signal stability improvement methods: delta-omega and delta P-omega stabilizers.

5. ENHANCEMENT OF SMALL SIGNAL STABILITY 9

Power System Stabilizer - Stabilizer based on shaft speed signal (delta omega) - Delta -P-Omega stabilizer-Frequency-based stabilizers - Digital Stabilizer - Excitation control design - Exciter gain - Phase lead compensation - Stabilizing signal washout stabilizer gain - Stabilizer limits

TOTAL: 45 hrs

REFERENCES:

1. P. Kundur, "Power System Stability and Control", McGraw-Hill, 1993.
2. IEEE Committee Report, "Dynamic Models for Steam and Hydro Turbines in Power System Studies", IEEE Trans., Vol.PAS-92, pp 1904-1915, November/ December, 1973. on Turbine- Governor Model.
3. P.M Anderson and A.A Fouad, "Power System Control and Stability", Iowa State University Press, Ames, Iowa, 1978.
4. R.Ramanujam, Power system dynamics, Analysis and Simulation, Prentice Hall India Learning Pvt. Ltd., New Delhi, 2009.

EE 608 FLEXIBLE A.C. TRANSMISSION SYSTEMS

L	T	P	C
3	0	0	3

OBJECTIVE:

1. To understand the working principles of different types of shunt and series FACTs Controllers.
2. To understand and derive the steady state model of FACTS devices suitable for use in power system studies.
3. To understand the dynamic models of FACTS devices suitable for use in transient stability programs.

1. INTRODUCTION 9

Reactive power control in electrical power transmission lines -Uncompensated transmission line - series compensation - Basic concepts of static Var Compensator (SVC) - Thyristor Controlled Series capacitor (TCSC) - Unified power flow controller (UPFC).

2. STATIC VAR COMPENSATOR (SVC) AND APPLICATIONS 9

Voltage control by SVC - Advantages of slope in dynamic characteristics - Influence of SVC on system voltage - Design of SVC voltage regulator - Modelling of svc for power flow and transient stability - Applications: Enhancement of transient stability - Steady state power transfer - Enhancement of power system damping - Prevention of voltage instability.

3. THYRISTOR CONTROLLED SERIES CAPACITOR (TCSC) AND APPLICATIONS 9

Operation of the TCSC - Different modes of operation - Modelling of TCSC - Variable reactance model - Modeling for Power Flow and stability studies. Applications: Improvement of the system stability limit - Enhancement of system damping.

4. VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS 9

Static Synchronous Compensator (STATCOM) - Principle of operation - V-I Characteristics. Applications: Steady state power transfer-Enhancement of transient stability - Prevention of voltage instability. SSSC-operation of SSSC and the control of power flow -Modeling of SSSC in load flow and transient stability studies. Applications: SSR Mitigation-UPFC and IPFC

5. CO-ORDINATION OF FACTS CONTROLLERS 9

Controller interactions - SVC - SVC interaction - Co-ordination of multiple controllers using linear control techniques - Control coordination using genetic algorithms.

TOTAL: 45 hrs

REFERENCES:

1. R.Mohan Mathur, Rajiv K.Varma, "Thyristor - Based FACTS Controllers for Electrical Transmission Systems", IEEE press and John Wiley & Sons, Inc.
2. Narain G. Hingorani, "Understanding FACTS -Concepts and Technology of Flexible AC Transmission Systems", Standard Publishers Distributors, Delhi-110 006
3. K.R.Padiyar," FACTS Controllers in Power Transmission and Distribution", New Age International(P) Limited, Publishers, New Delhi, 2008
4. A.T.John, "Flexible A.C. Transmission Systems", Institution of Electrical and Electronic Engineers (IEEE), 1999.
5. V.K.Sood, HVDC and FACTS controllers - Applications of Static Converters in Power System, APRIL 2004, Kluwer Academic Publishers.

EE 609 RESTRUCTURED POWER SYSTEMS

	L	T	P	C
	3	0	0	3

OBJECTIVE:

To present a background on restructuring of power system which has taken place in many countries in the world including our country, to provide insight on new trends in operation and control in deregulated power systems and to highlight electric energy trading in the electricity market.

1. OVERVIEW OF KEY ISSUES IN ELECTRIC UTILITIES RESTRUCTURING 9

Restructuring Models: PoolCo Model, Bilateral Contracts Model, Hybrid Model - Independent System Operator (ISO): The Role of ISO - Power Exchange(PX): Market Clearing Price(MCP) - Market operations: Day-ahead and Hour-Ahead Markets, Elastic and Inelastic Markets - Market Power - Stranded costs - Transmission Pricing: Contract Path Method, The MW-Mile Method - Congestion Pricing: Congestion Pricing Methods, Transmission Rights - Management of Inter-Zonal/Intra Zonal Congestion: Solution procedure, Formulation of Inter-Zonal Congestion Sub problem, Formulation of Intra-Zonal Congestion Sub problem.

2. ELECTRIC UTILITY MARKETS IN THE UNITED STATES 9

California Markets: ISO, Generation, Power Exchange, Scheduling Co-ordinator, UDCs, Retailers and Customers, Day-ahead and Hour-Ahead Markets, Block forwards Market, Transmission Congestion Contracts(TCCs) - New York Market: Market operations - PJM interconnection - Ercot ISO - New England ISO - Midwest ISO: MISO's Functions, Transmission Management, Transmission System Security, Congestion Management, Ancillary Services Coordination, Maintenance Schedule Coordination - Summary of functions of U.S. ISOs.

3. OASIS: OPEN ACCESS SAME-TIME INFORMATION SYSTEM 9

FERC order 889 - Structure of OASIS: Functionality and Architecture of OASIS - Implementation of OASIS Phases: Phase 1, Phase 1-A, Phase 2 - Posting of information: Types of information available on OASIS, Information requirement of OASIS, Users of OASIS - Transfer Capability on OASIS: Definitions, Transfer Capability Issues, ATC Calculation, TTC Calculation, TRM Calculation, CBM Calculation - Transmission Services - Methodologies to Calculate ATC - Experiences with OASIS in some Restructuring Models: PJM OASIS, ERCOT OASIS.

4. ELECTRIC ENERGY TRADING 9

Essence of Electric Energy Trading - Energy Trading Framework: The Qualifying factors - Derivative Instruments of Energy Trading: Forward Contracts, Futures Contracts, Options, Swaps, Applications of Derivatives in Electric Energy Trading - Port Folio Management: Effect of Positions on Risk Management - Energy Trading Hubs - Brokers in Electricity Trading - Green Power Trading.

5. SPECIAL COMPUTATIONAL TECHNIQUES 9

Formulation of D.C. Optimal Power Flow (DCOPF) model for- Assessment of Available Transfer Capability (ATC)- Assessment of Simultaneous ATC (SATC)- Congestion Management.-Solution of the above problems using the LR technique-Numerical examples for the above problems

TOTAL: 45 hours

TEXT BOOK:

Mohammad Shahidehpour and Muwaffaq Almoush, "Restructured Electrical Power Systems:

Operation, Trading and Volatility", Marcel Dekkar, Inc., 2001.

REFERENCES:

1. G.Zaccour, "Deregulation of Electric Utilities", Kluwer Academic Publishers 1998.
2. M.Illic, F. Galiana and L.Fink, "Power Systems Restructuring : Engineering and Economics",Kluwer Academic Publishers, 2000.
3. Editor: Loi Lei Lai, "Power System Restructuring and Deregulation: Trading, Performance and Information Technology", John Wiley and sons Ltd, 2001.
4. K.Bhattacharya, M.H.J.Bollen and J.E.Daader, "Operation of Restructured Power Systems", Kluwer Academic Publishers, 2001.
5. F.C.Schweppe, M.C.Caramanis, R.D.Tabors and R.E.Bohn, "Spot Pricing of Electricity", Kluwer Academic Publishers, 2002.
6. J.H.Chow,F.F.Wu and J.A.Momoh, "Applied Mathematics for restructured electric power systems:Optimization, Control and Computation Intelligence", Springer 2004.

EE 610 POWER SYSTEM SIMULATION LABORATORY-II

L	T	P	C
0	0	3	2

OBJECTIVE:

1. To analyse the small signal stability of power system with simple machine models.
2. To study the effect of controllers like AVR, PSS, Governor in small signal stability of power systems.
3. To develop models for FACTS devices for steady state and dynamic analysis.

LIST OF EXPERIMENTS:

1. Development of small signal stability program for single machine infinite bus system using classical machine model using MATLAB.
2. Development of small signal stability program for multimachine power system using classical machine model using MATLAB.
3. Co-ordination of over-current and distance relays for radial line protection using ETAP.
4. Induction motor starting analysis using EUROSTAG.
5. Load flow analysis of two-bus system with STATCOM.
6. Transient analysis of single machine infinite bus system with STATCOM using MATLAB.
7. Available Transfer Capability calculation using repeated load flow and DCOPF method.
8. Small signal stability enhancement with TCSC in a SMIB system using MATLAB.
9. Transient stability analysis of power system with fixed speed induction generator using CYME.
10. Transient stability analysis of power system with doubly fed induction generator using CYME.
11. Computation of harmonic indices generated by a rectifier feeding an R-L load using PSPICE.

ELECTIVES

EEY 001 ELECTROMAGNETIC FIELD COMPUTATION AND MODELLING

L	T	P	C
3	0	0	3

OBJECTIVE:

To impart knowledge on modelling and analysis of electrical systems such as insulators, transformers, lightning arresters and various types of electric machines using the Finite Element Analysis.

1. INTRODUCTION 9

Review of basic field theory - electric and magnetic fields - Maxwell's equations - Laplace, Poisson and Helmoltz equations - principle of energy conversion - force/torque calculation - Electro thermal formulation.

2. SOLUTION OF FIELD EQUATIONS I 9

Limitations of the conventional design procedure, need for the field analysis based design, problem definition , solution by analytical methods-direct integration method - variable separable method - method of images, solution by numerical methods- Finite Difference Method.

3. SOLUTION OF FIELD EQUATIONS II 9

Finite element method (FEM) - Differential/ integral functions - Variational method - Energy minimization - Discretisation - Shape functions -Stiffness matrix -1D and 2D planar and axial symmetry problem.

4. FIELD COMPUTATION FOR BASIC CONFIGURATIONS 9

Computation of electric and magnetic field intensities- Capacitance and Inductance - Force, Torque, Energy for basic configurations.

5. DESIGN APPLICATIONS 9

Insulators- Bushings - Cylindrical magnetic actuators - Transformers - Rotating machines.

L=45: T=15

TOTAL =60 hrs

REFERENCES:

1. K.J.Binns, P.J.Lawrenson, C.W Trowbridge, "The analytical and numerical solution of Electric and magnetic fields", John Wiley & Sons, 1993.
2. Nathan Ida, Joao P.A.Bastos , "Electromagnetics and calculation of fields", Springer- Verlage, 1992.
3. Nicola Biyanchi, "Electrical Machine analysis using Finite Elements", Taylor and Francis Group, CRC Publishers, 2005.
4. S.J Salon, "Finite Element Analysis of Electrical Machines." Kluwer Academic Publishers, London, 1995, distributed by TBH Publishers & Distributors, Chennai, India
5. User manuals of MAGNET, MAXWELL & ANSYS software.
6. Silvester and Ferrari, "Finite Elements for Electrical Engineers" Cambridge University press, 1983.

EEY 002 ANALYSIS OF ELECTRICAL MACHINES

L	T	P	C
3	0	0	3

OBJECTIVE:

To impart knowledge on Reference frame theory, Transformational variables and Analysis of conventional machines (DC machines, Induction machines and synchronous machines) using the Reference frame theory to predict torque, output and performance of the machine.

1. PRINCIPLES OF ELECTROMAGNETIC ENERGY CONVERSION 9

General expression of stored magnetic energy, co-energy and force/ torque - example using single and doubly excited system -Calculation of air gap mmf and per phase machine inductance using physical machine data.

2. REFERENCE FRAME THEORY 9

Static and rotating reference frames - transformation of variables - reference frames - transformation between reference frames - transformation of a balanced set -balanced steady state phasor and voltage equations - variables observed from several frames of reference.

3. DC MACHINES 9

Voltage and toque equations - dynamic characteristics of permanent magnet and shunt DC motors - state equations - solution of dynamic characteristic by Laplace transformation.

4. INDUCTION MACHINES 9

Voltage and toque equations - transformation for rotor circuits - voltage and torque equations in reference frame variables - analysis of steady state operation - free acceleration characteristics - dynamic performance for load and torque variations - dynamic performance for three phase fault - computer simulation in arbitrary reference frame.

5. SYNCHRONOUS MACHINES 9

Voltage and Torque Equation - voltage Equation in arbitrary reference frame and rotor reference frame - Park equations - rotor angle- steady state analysis - dynamic performances for torque variations- dynamic performance for three phase fault - transient stability limit - critical clearing time - computer simulation.

TOTAL : 45 hrs

TEXT BOOKS:

1. Paul C.Krause, OlegWasyzczuk, Scott S, Sudhoff, "Analysis of Electric Machinery and Drive Systems", IEEE Press, Second Edition.

2. R.Krishnan, "Electric Motor Drives, Modeling, Analysis and Control" , Prentice Hall of India, 2002

REFERENCES:

1. Samuel Seely, " Electromechanical Energy Conversion", Tata McGraw Hill Publishing Company,

2. A.E, Fitzgerald, Charles Kingsley, Jr, and Stephan D, Umanx, " Electric Machinery", Tata McGraw Hill, 5th Edition, 1992

EEY 003 EHV POWER TRANSMISSION

L	T	P	C
3	0	0	3

OBJECTIVE:

1. To Understand the importance and functioning of EHV Power Transmission
2. To be familiar with standard transmission voltages and different configurations of EHV Power Transmission
3. To study the calculation procedure of Line parameters, Electrostatic field, Voltage gradient of conductors and corona effects in EHV Power Transmission.

1. INTRODUCTION 9

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

2. CALCULATION OF LINE PARAMETERS 9

Calculation of resistance, inductance and capacitance for multi-conductor lines - calculation of sequence inductances and capacitances - line parameters for different modes of propagation - resistance and inductance of ground return, numerical example involving a typical 400/220kV line using line constant program.

3. VOLTAGE GRADIENTS OF CONDUCTORS 9

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

4. CORONA EFFECTS 9

Power losses and audible losses: I2R loss and corona loss - audible noise generation and characteristics - limits for audible noise - Day-Night equivalent noise level- radio interference: corona pulse generation and properties - limits for radio interference fields.

5. ELECTROSTATIC FIELD OF EHV LINES 9

Effect of EHV line on heavy vehicles - calculation of electrostatic field of AC lines- effect of high field on humans, animals, and plants - measurement of electrostatic fields - electrostatic Induction in unenergised circuit of a D/C line - induced voltages in insulated ground wires - electromagnetic interference.

TOTAL: 45 hrs

REFERENCES:

1. Rakosh Das Begamudre, "Extra High Voltage AC Transmission Engineering", Second Edition, New Age International Pvt. Ltd., 1990.
2. Power Engineer's Handbook, Revised and Enlarged 6th Edition, TNEB Engineers' Association, October 2002.
3. Microtran Power System Analysis Corporation, Microtran Reference Manual, Vancouver Canada. (Website: www.microtran.com).

EEY 004 SPECIAL ELECTRICAL MACHINES

L	T	P	C
3	0	0	3

OBJECTIVE:

To impart knowledge on Special electric machines - general discussion, Stepper motors,Switched reluctance motors and Permanent magnet machines.

1. SYNCHRONOUS RELUCTANCE MOTORS 9

Constructional features: axial and radial air gap Motors. Operating principle, reluctance torque - phasor diagram, motor characteristics - Linear induction machines.

2. STEPPING MOTORS 9

Constructional features, principle of operation, modes of excitation torque production in Variable Reluctance (VR) stepping motor, dynamic characteristics, Drive systems and circuit for open loop control, closed loop control of stepping motor.

3. SWITCHED RELUTANCE MOTORS 9

Constructional features-principle of operation-Torque equation-Power Controllers-Characteristics and control Microprocessor based controller.

4. PERMANENT MAGNET SYNCHRONOUS MOTORS 9

Principle of operation, EMF, power input and torque expressions, Phasor diagram, Power controllers, Torque speed characteristics, Self control, Vector control, Current control schemes.

5. PERMANENT MAGNET BRUSHLESS DC MOTORS 9

Commutation in DC motors, Difference between mechanical and electronic commutators, Hall sensors, Optical sensors, Multiphase Brushless motor, Square wave permanent magnet brushless motor drives, Torque and emf equation, Torque-speed characteristics, Controllers-Microprocessor based controller.

TOTAL: 45 hrs

TESXT BOOKS:

1. Miller, T.J.E. "Brushless permanent magnet and reluctance motor drives", Clarendon Press, Oxford, 1989.

2. Kenjo, T, "Stepping motors and their microprocessor control ", Clarendon Press, Oxford, 1989.

REFERENCES:

1. Kenjo, T and Naganori, S "Permanent Magnet and brushless DC motors ", Clarendon Press, Oxford, 1989.
2. Kenjo, T. Power Electronics for the microprocessor Age, 1989.
3. B.K. Bose, "Modern Power Electronics & AC drives"
4. R.Krishnan, "Electric Motor Drives - Modeling, Analysis and Control", Prentice-Hall of India Pvt. Ltd., New Delhi, 2003

EEY 005 POWER QUALITY

L	T	P	C
3	0	0	3

OBJECTIVE:

The main objective of the course is to enhance the knowledge of the participants in the emerging area of power quality and several key issues related to its modeling, assessment and mitigation. The course will provide a platform to an in-depth discussion on the various challenges and their possible remedies with respect to maintaining power quality in electricity sector, which will benefit participants from academic and R & D institutions, professional engineers from utilities, industries and policy makers

1. INTRODUCTION 9

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

2. NON-LINEAR LOADS 9

Single phase static and rotating AC/DC converters, Three phase static AC/DC converters, Battery chargers, Arc furnaces, Fluorescent lighting, pulse modulated devices, Adjustable speed drives.

3. MEASUREMENT AND ANALYSIS METHODS 9

Voltage, Current, Power and Energy measurements, power factor measurements and definitions, event recorders, Measurement Error - Analysis: Analysis in the periodic steady state, Time domain methods, Frequency domain methods: Laplace's, Fourier and Hartley transform - The Walsh Transform - Wavelet Transform.

4. ANALYSIS AND CONVENTIONAL MITIGATION METHODS 9

Analysis of power outages, Analysis of unbalance: Symmetrical components of phasor quantities, Instantaneous symmetrical components, Instantaneous real and reactive powers, Analysis of distortion: On-line extraction of fundamental sequence components from measured samples - Harmonic indices - Analysis of voltage sag: Detorit Edison sag score, Voltage sag energy, Voltage Sag Lost Energy Index (VSLEI)- Analysis of voltage flicker, Reduced duration and customer impact of outages, Classical load balancing problem: Open loop balancing, Closed loop balancing, current balancing, Harmonic reduction, Voltage sag reduction.

5. POWER QUALITY IMPROVEMENT 9

Utility-Customer interface -Harmonic filters: passive, Active and hybrid filters -Custom power devices: Network reconfiguring Devices, Load compensation using DSTATCOM, Voltage regulation using DSTATCOM, protecting sensitive loads using DVR, UPQC -control strategies: P-Q theory, Synchronous detection method - Custom power park -Status of application of custom power devices.

TOTAL: 45 hrs

TESXT BOOKS:

1. Arindam Ghosh "Power Quality Enhancement Using Custom Power Devices", Kluwer Academic Publishers, 2002
2. G.T.Heydt, "Electric Power Quality", Stars in a Circle Publications, 1994 (2nd edition)
3. Power Quality - R.C. Duggan
4. Power system harmonics -A.J. Arrillga
5. Power electronic converter harmonics -Derek A. Paice.

EEY 006 POWER SYSTEM PLANNING AND RELIABILITY **L T P C**
3 0 0 3

OBJECTIVE:

1. To familiarize with the different types of load forecasting techniques used in power systems.
2. To study the different types of indices used in power system reliability studies.
3. To understand the distribution system planning problem and capacitor placement problem.

1. LOAD FORECASTING 9

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

2. GENERATION SYSTEM RELIABILITY ANALYSIS 9

Probabilistic generation and load models- Determination of LOLP and expected value of demand not served -Determination of reliability of iso and interconnected generation systems.

3. TRANSMISSION SYSTEM RELIABILITY ANALYSIS 9

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

4. EXPANSION PLANNING 9

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

5. DISTRIBUTION SYSTEM PLANNING OVERVIEW 9

Introduction, sub transmission lines and distribution substations-Design primary and secondary systems-distribution system protection and coordination of protective devices.

TOTAL: 45 hrs

REFERENCES:

1. Proceeding of work shop on energy systems planning & manufacturing CI.
2. R.L .Sullivan, "Power System Planning".
3. Roy Billinton and Allan Ronald, "Power System Reliability."
4. Turan Gonen, Electric power distribution system Engineering 'McGraw Hill, 1986

EEY 007 ADVANCED DIGITAL SIGNAL PROCESSING **L T P C**
3 0 0 3

OBJECTIVE:

Signal Processing is considered as an important component in every emerging field such as Remote Sensing, Biomedical, Seismology, Wireless Communications, Multimedia, Space & Earth Exploration and Military applications etc.To get exposed to various implementation aspects of Advanced DSP algorithms in FPGA and DSP processors for different applications.

1. Program a DSP chip to filter signals using either assembly language or a C Compiler for the chip. This filter could be a FIR or IIR filter. The student should understand how to design algorithms for implementation.
2. Understand how digital to analog (D/A) and analog to digital (A/D) converters operate on a signal and should be able to model these operations mathematically.
3. Use Z transforms and discrete time Fourier transforms to analyze a digital system.

1. INTRODUCTION 9

Mathematical description of change of sampling rate - Interpolation and Decimation, Filter implementation for sampling rate conversion - direct form FIR structures, DTFT, FFT, Wavelet transform and filter bank implementation of wavelet expansion of signals

2. ESTIMATION AND PREDICTION TECHNIQUES 9

Discrete Random Processes - Ensemble averages, Stationary processes, Autocorrelation and Auto covariance matrices. Parseval's Theorem, Wiener-Khintchine Relation - Power Spectral Density. AR, MA, ARMA model based spectral estimation. Parameter Estimation, Linear prediction - Forward and backward predictions, Least mean squared error criterion - Wiener filter for filtering and prediction, Discrete Kalman filter.

3. DIGITAL SIGNAL PROCESSOR 9

Basic Architecture - Computational building blocks, MAC, Bus Architecture and memory, Data Addressing, Parallelism and pipelining, Parallel I/O interface, Memory Interface, Interrupt, DMA.

4. APPLICATION OF DSP 9

Design of Decimation and Interpolation Filter, FFT Algorithm, PID Controller, Application for Serial Interfacing, DSP based Power Meter, Position control.

5. VLSI IMPLEMENTATION 9

Basics on DSP sytem architecture design using VHDL programming, Mapping of DSP algorithm onto hardware, Realisation of MAC & Filter structure.

TOTAL: 45 hrs

REFERENCES:

1. Bernard Widrow, Samuel D. Stearns, "Adaptive Signal Processing", Pearson Education, third edition, 2004.
2. Dionitris G. Manolakis, Vinay K. Ingle, Stepen M. Kogon,"Statistical & Adaptive signal processing, spectral estimation, signal modeling, Adaptive filtering & Array processing", McGraw-Hill International edition 2000.
3. Monson H. Hayes, "Statistical Digital Signal Processing and Modelling", John Wiley and Sons, Inc.,
4. John G. Proaks, Dimitris G. Manolakis, "Digital Signal Processing", Pearson Education 2002.
5. S. Salivahanan, A. Vallavaraj and C. Gnanapriya "Digital Signal Processing", TMH, 2000.
6. Avatar Sing, S. Srinivasan, "Digital Signal Processing- Implementation using DSP Microprocessors with Examples from TMS320C54xx", Thomson India, 2004.
7. Lars Wanhammer, "DSP Integrated Circuits", Academic press, 1999, New York.
8. Ashok Ambardar,"Digital Signal Processing: A Modern Introduction", Thomson India edition, 2007.
9. Lars Wanhammer, "DSP Integrated Circuits", Academic press, 1999, New York.

EEY 008 CONTROL SYSTEM DESIGN

L	T	P	C
3	0	0	3

OBJECTIVE:

The course aims at giving an exhaustive exposure to various methods of control system design. Design in Discrete Domain and effect of sampling is also stressed. Optimal control techniques like calculus of variation and Riccati's equation are discussed with examples. State Estimation by filtering and observer techniques is also discussed. Discrete state variable design by dynamic programming is achived.

1. CONVENTIONAL DESIGN METHODS 9

Design specifications- PID controllers and compensators- Root locus based design- Bode based design-Design examples

2. DESIGN IN DISCRETE DOMAIN 9

Sample and Hold-Digital equivalents-Impulse and step invariant transformations-Methods of discretisation-Effect of sampling- Direct discrete design - discrete root locus Design examples

3. OPTIMAL CONTROL 9

Formation of optimal control problems-results of Calculus of variations-Hamiltonian formulation-solution of optimal control problems- Evaluation of Riccati's equation-State and output Regulator problems-Design examples

4. DISCRETE STATE VARIABLE DESIGN 9

Discrete pole placement- state and output feedback-estimated state feedback-discrete optimal control- dynamic programming-Design examples

5. STATE ESTIMATION 9

State Estimation Problem -State estimation- Luenberger's observer-noise characteristics- Kalman-Bucy filter-Separation Theorem-Controller Design-Wiener filter-Design examples.

TOTAL: 45 hrs

REFERENCES:

1. M. Gopal "Modern control system Theory" New Age International, 2005.
2. Benjamin C. Kuo "Digital control systems", Oxford University Press, 2004.

3. G. F. Franklin, J. D. Powell and A. E. Naeini "Feedback Control of Dynamic Systems", PHI (Pearson), 2002.

4. Graham C. Goodwin, Stefan F. Graebe and Mario E. Salgado "Control system Design", PHI (Pearson), 2003.

5. G. F. Franklin, J. D. Powell and M Workman, "Digital Control of Dynamic Systems", PHI (Pearson), 2002.

6. B.D.O. Anderson and J.B. Moore., 'Optimal Filtering', Prentice hall Inc., N.J., 1979.

7. Loan D. Landau, Gianluca Zito," Digital Control Systems, Design, Identification and Implementation", Springer, 2006.

EEY 009 HIGH VOLTAGE SWITCHGEAR

L	T	P	C
3	0	0	3

OBJECTIVE:

As Switch Gear is an important link in any Power System network, including Transmission and Distribution systems, this course aims to provide a holistic view of all the aspects of Switch Gear.

By the end of the semester, each student will be able to do the following:

- Be able to understand the concept of insulation clearance in the medium like Air, Oil, SF6, Vacuum etc.
- Be able to understand the various characteristics and phenomena of "Arc"
- Be able to assimilate a comprehensive knowledge on various types of Circuit Breakers and their applications
- The testing technique, short circuit calculation and rating of Circuit Breaker will be understood

1. Introduction 7

Insulation of switchgear - rated and tested voltage co-ordination between inner and external insulation. Insulation clearances in air, oil SF6 and vacuum, bushing insulation, solid insulating materials - dielectric and mechanical strength consideration.

2. Circuit Interruption 10

Switchgear terminology - Arc characteristics - direct and alternating current interruption - arc quenching phenomena - computer simulation of arc models - transient re-striking voltage - RRRV - recovery voltage - current chopping - capacitive current breaking - auto re-closing.

3. Short circuit calculations and rating of circuit breakers 10

Types of faults in Power systems-short circuit current and short circuit MVA calculations for different types of faults-ratings of circuit breakers - symmetrical and asymmetrical ratings.

4. Circuit Breakers 10

Classifications of circuit breakers-design, construction and operating principles of bulk oil, minimum oil, airblast, SF6 and vacuum circuit breakers - comparison of different types of circuit breakers.

5. Testing of Circuit Breakers 8

Type tests and routine tests - short circuit testing - synthetic testing of circuit breakers - recent advancements in high voltage circuit breakers - diagnosis.

TOTAL: 45 hrs

REFERENCES:

1. Chunikhin A and Zhavoronkov M., "High Voltage Switchgear analysis and Design", Mir Publishers, MOSCOW, 1989.
2. Kuffel E., Zaengl, W.S., and Kuffel J., High Voltage Enginering Fundamentals, Newness, Second edition , Butterworth - Heinemann publishers, New Delhi, 2000
3. Flursscheim, C.H. (Editor), Power Circuit breaker - theory and design, IEE Monograph series 17, Peter Peregrinus Ltd. Southgatge House, Stevenage, Herts, SC1 1HQ, Englsand, 1977.
4. Anathakrishnan S and Guruprasad K.P., Transient Recovery Voltage and Circuit Breakers, Tata McGraw Hill Publishing company ltd., New Delhi, 1999.

EEY 010 OPTIMAL CONTROL AND FILTERING

L	T	P	C
3	0	0	3

OBJECTIVE:

Various optimal control formulations like Pontryagin's minimum principle are dealt with. Dynamic programming and numerical techniques of solution for optimal control are compared and evaluated. Filtering techniques like Kalman Filter and Estimation are also covered.

1. INTRODUCTION 9

Statement of optimal control problem - Problem formulation and forms of optimal Control - Selection of performance measures. Necessary conditions for optimal control - Pontryagin's minimum principle - State inequality constraints - Minimum time problem.

2. LQ CONTROL PROBLEMS AND DYNAMIC PROGRAMMING 9

Linear optimal regulator problem - Matrix Riccatti equation and solution method - Choice of weighting matrices - Steady state properties of optimal regulator - Linear tracking problem - LQG problem - Computational procedure for solving optimal control problems - Characteristics of dynamic programming solution - Dynamic programming application to discrete and continuous systems - Hamilton Jacobi Bellman equation.

3. NUMERICAL TECHNIQUES FOR OPTIMAL CONTROL 9

Numerical solution of 2-point boundary value problem by steepest descent and Fletcher Powell method solution of Ricatti equation by negative exponential and interactive Methods.

4. FILTERING AND ESTIMATION 9

Filtering - Linear system and estimation - System noise smoothing and prediction -Gauss Markov discrete time model - Estimation criteria - Minimum variance estimation - Least square estimation - Recursive estimation.

5. KALMAN FILTER AND PROPERTIES 9

Filter problem and properties - Linear estimator property of Kalman Filter - Time invariance and asymptotic stability of filters - Time filtered estimates and signal to noise ratio improvement - Extended Kalman filter.

TOTAL: 45 hrs

REFERENCES:

1. Kirk D.E., 'Optimal Control Theory - An introduction', Prentice hall, N.J., 1970.
2. Sage, A.P., 'Optimum System Control', Prentice Hall N.H., 1968.
3. Anderson, BD.O. and Moore J.B., 'Optimal Filtering', Prentice hall Inc., N.J., 1979.
4. S.M. Bozic, "Digital and Kalman Filtering", Edward Arnould, London, 1979.
5. Astrom, K.J., "Introduction to Stochastic Control Theory", Academic Press, Inc, N.Y., 1970.

EEY 011 ADVANCED POWER SYSTEM DYNAMICS **L T P C**
3 0 0 3

OBJECTIVE:

1. To Understand and familiarize with different type of numerical integration algorithms used for transient stability analysis of power systems.
2. To understand the phenomena of sub-synchronous resonance and model power system components suitably to analyze sub-synchronous oscillations.
3. To understand the phenomena of voltage instability in power systems.

1. TRANSIENT STABILITY ANALYSIS [1,2,3] 9

Review of numerical integration methods: Euler and Fourth Order Runge-Kutta methods, Numerical stability and implicit methods, Simulation of Power System Dynamic response: Structure of Power system Model, Synchronous machine representation: equations of motion, rotor circuit equations, stator voltage equations, Thevenin's and Norton's equivalent circuits, Excitation system representation, Transmission network and load representation, Overall system equations and their solution: Partitioned - Explicit and Simultaneous-implicit approaches, treatment of discontinuities, Simplified Transient Stability Simulation using implicit integration method.

2. SUBSYNCHRONOUS OSCILLATIONS [1] 9

Introduction - Turbine Generator Torsional Characteristics: Shaft system model - Examples of torsional characteristics - Torsional Interaction with Power System Controls: Interaction with generator excitation controls - Interaction with speed governors - Interaction with nearby DC converters.

3. SUBSYSNCHRONOUS RESONANCE (SSR) [1,4] 9

Subsysnchronous Resonance (SSR): Characteristics of series compensated transmission systems - Self-excitation due to induction generator effect - Torsional interaction resulting in SSR - Analytical Methods - Numerical examples illustrating instability of subsynchronous oscillations - Impact of Network-Switching Disturbances: Steady-state switching - Successive network-Switching disturbances - Torsional Interaction Between Closely Coupled Units; time-domain simulation of subsynchronous resonance - EMTP with detailed synchronous machine model

4. TRANSMISSION, GENERATION AND LOAD ASPECTS OF VOLTAGE STABILITY ANALYSIS [5] 9

Review of transmission aspects - Generation Aspects: Review of synchronous machine theory - Voltage and frequency controllers - Limiting devices affecting voltage stability - Voltage-reactive power characteristics of synchronous generators - Capability curves - Effect of machine limitation on deliverable power - Load Aspects - Voltage dependence of loads - Load restoration dynamics - Induction motors - Load tap changers - Thermostatic load recovery - General aggregate load models.

5 . ENHANCEMENT OF TRANSIENT STABILITY AND COUNTER MEASURES FOR SUB SYNCHRONOUS RESONANCE [1] 9

Principle behind transient stability enhancement methods: high-speed fault clearing, reduction of transmission system reactance, regulated shunt compensation, dynamic braking, reactor switching, independent pole-operation of circuit-breakers, single-pole switching, fast-valving, high-speed excitation systems; NGH damper scheme.

TOTAL: 45 hrs

REFERENCES:

1. P. Kundur, Power System Stability and Control, McGraw-Hill, 1993.
2. H.W. Dommel and N.Sato, "Fast Transient Stability Solutions," IEEE Trans., Vol. PAS-91, pp, 1643-1650, July/August 1972.
3. AU Power Lab Laboratory Manuals, Anna University, pp : 7-1 to 7-12, May 2004.
4. H. W. Dommel, EMTP THEORY BOOK, Microtran Power System Analysis Corporation, Second Edition, 1996.
5. T.V. Cutsem and C.Vournas, "Voltage Stability of Electric Power Systems", Kluwer Publishers, 1998.

EEY 012	**SYSTEM IDENTIFICATION AND ADAPTIVE CONTROL**	**L T P C** **3 0 0 3**

OBJECTIVE:

Models for identification of linear and non linear systems and fuzzy models are studied. Parametric and non-parametric identification and adaptive control and adaptation techniques are discussed. Case studies like inverted pendulum and robotic arm are also discussed in depth.

1. MODELS FOR INDENTIFICATION 9

Models of LTI systems: Linear Models-State space Models-OE model- Model sets, Structures and Identifiability-Models for Time-varying and Non-linear systems: Models with Nonlinearities - Non-linear state-space models-Black box models, Fuzzy models'.

2. NON-PARAMETRIC AND PARAMETRIC IDENTIFICATON 9

Transient response and Correlation Analysis - Frequency response analysis - Spectral Analysis - Least Square - Recursive Least Square -Forgetting factor-Maximum Likelihood - Instrumental Variable methods.

3. NON-LINEAR IDENTIFICATION AND MODEL VALIDATION 9

Open and closed loop identification: Approaches - Direct and indirect identification - Joint input-output identification - Non-linear system identification - Wiener models - Power series expansions - State estimation techniques - Non linear identification using Neural Network and Fuzzy Logic.

4. ADAPTIVE COTROL AND ADAPTATION TECHNIQUES 9

Introduction - Uses - Auto tuning - Self Tuning Regulators (STR) - Model Reference Adaptive Control (MRAC) - Types of STR and MRAC - Different approaches to self-tuning regulators - Stochastic Adaptive control - Gain Scheduling.

5. CASE STUDIES 9

Inverted Pendulum, Robot arm, process control application: heat exchanger, Distillation column, application to power systems- Adaptive Power System Stabilizer.

TOTAL: 45 hrs

REFERENCES:

1. Ljung," System Identification Theory for the User", PHI, 1987.
2. Torsten Soderstrom, Petre Stoica, "System Identification", Prentice Hall International (UK) Ltd, 1989.
3. Astrom and Wittenmark," Adaptive Control", PHI
4. William S. Levine, "Control Hand Book".
5. Narendra and Annasamy," Stable Adaptive Control Systems, Prentice Hall, 1989.

EEY 013 INDUSTRIAL POWER SYSTEM ANALYSIS AND DESIGN

L	T	P	C
3	0	0	3

OBJECTIVE:

1. To understand the calculations used with induction motor starting studies.
2. To understand and calculate harmonic indices in power quality studies.
3. To study and calculate the rating of capacitors for power factor correction studies.
4. To introduce computer analysis methods for ground grid calculations.

1. MOTOR STARTING STUDIES 9

Introduction-Evaluation Criteria-Starting Methods-System Data-Voltage Drop Calculations-Calculation of Acceleration time-Motor Starting with Limited-Capacity Generators-Computer-Aided Analysis-Conclusions.

2. POWER FACTOR CORRECTION STUDIES 9

Introduction-System Description and Modeling-Acceptance Criteria-Frequency Scan Analysis-Voltage Magnification Analysis-Sustained Overvoltages-Switching Surge Analysis-Back-to-Back Switching-Summary and Conclusions.

3. HARMONIC ANALYSIS 9

Harmonic Sources-System Response to Harmonics-System Model for Computer-Aided Analysis-Acceptance Criteria-Harmonic Filters-Harmonic Evaluation-Case Study-Summary and Conclusions.

4. FLICKER ANALYSIS 9

Surces of Flicker-Flicker Analysis-Flicker Criteria-Data for Flicker analysis-Case Study-Arc Furnace Load-Minimizing the Flicker Effects-Summary.

5. GROUND GRID ANALYSIS 9

Introduction-Acceptance Criteria-Ground Grid Calculations-Computer-Aided Analysis - Improving the Performance of the Grounding Grids-Conclusions.

TOTAL: 45 hrs

REFERENCES:

1. Ramasamy Natarajan,"Computer-Aided Power System Analysis", Marcel Dekker Inc., 2002.

EEY 014 HIGH VOLTAGE DIRECT CURRENT TRANSMISSION **L T P C**
3 0 0 3

OBJECTIVE:

1. To mould the students to acquire knowledge about HVDC Transmission systems.
2. To impart basic ideas about HVDC converters and system control.
3. To introduce the concept of Multi Terminal DC systems.

1. DC POWER TRANSMISSION TECHNOLOGY 6

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

2. ANALYSIS OF HVDC CONVERTERS AND HVDC SYSTEM CONTROL 12

Pulse number, choice of converter configuration - Simplified analysis of Graetz circuit - Converter bridge characteristics - characteristics of a twelve pulse converter- detailed analysis of converters.

General principles of DC link control - Converter control characteristics - System control hierarchy - Firing angle control - Current and extinction angle control - Generation of harmonics and filtering - power control - Higher level controllers.

3. MULTITERMINAL DC SYSTEMS 9

Introduction - Potential applications of MTDC systems - Types of MTDC systems - Control and protection of MTDC systems - Study of MTDC systems.

4. POWER FLOW ANALYSIS IN AC/DC SYSTEMS 9

Per unit system for DC Quantities - Modelling of DC links - Solution of DC load flow - Solution of AC-DC power flow - Case studies.

5. SIMULATION OF HVDC SYSTEMS 9

Introduction - System simulation: Philosophy and tools - HVDC system simulation - Modelling of HVDC systems for digital dynamic simulation - Dynamic interaction between DC and AC systems.

TOTAL: 45 hrs

REFERENCES:

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

EEY 015 WIND ENERGY CONVERSION SYSTEMS

L	T	P	C
3	0	0	3

OBJECTIVE:

1. To understand the working of wind energy conversion systems.
2. To study the modeling of different types of induction generators used with wind farms for steady state and transient analysis.
3. To become familiar with the different types of power quality problems created by wind farms in power systems.

1. INTRODUCTION 9

Components of WECS-WECS schemes-Power obtained from wind-simple momentum theory-Power coefficient-Sabinin's theory-Aerodynamics of Wind turbine.

2. WIND TURBINES 9

HAWT-VAWT-Power developed-Thrust-Efficiency-Rotor selection-Rotor design considerations-Tip speed ratio-No. of Blades-Blade profile-Power Regulation-yaw control-Pitch angle control-stall control-Schemes for maximum power extraction.

3. FIXED SPEED AND VARIABLE SPEED SYSTEMS 9

HAWT-VAWT-Power developed-Thrust-Efficiency-Rotor selection-Rotor design considerations-Tipspeed ratio-No. of Blades-Blade profile-Power Regulation-yaw control-Pitch angle control-stall control-Schemes for maximum power extraction. Need of variable speed systems-Power-wind speed characteristics-Variable speed constant frequency systems synchronous generator- DFIG.

4. INDUCTION GENERATOR MODELLING 9

Modelling of fixed speed induction generator - axes transformation- flux linkage equations- voltage equations- state equations - fifth order model- transient stability simulation of fixed speed induction generator using EUROSTAG 4.3-Doubly Fed Induction Generator(DFIG) modelling - controller modelling - modelling of DFIG in EUROSTAG - transient stability simulation of power systems with induction generators using EUROSTAG 4.3.

5. GRID CONNECTED SYSTEMS 9

Stand alone and Grid Connected WECS system-Grid connection Issues-Machine side & Grid side controllers-WECS in various countries

TOTAL:45

REFERENCES

1. L.L.Freris "Wind Energy conversion Systems", Prentice Hall, 1990
2. Jian Zhang, Adam Dysko, John O'Reilly, William E. Leithead," Modeling and performance of fixed-speed induction generators in power system oscillation stability studies", Electric Power System Research Vol. 78 (2008) 1416-1424.
3. Andre´s Feijoo, Jose Cidras, Camilo Carrillo, "A third order model for the doubly-fed induction machine", Electric Power Systems Research 56 (2000) 121-127.
4. Eurostag 4.3 Theory Manual Part I.
5. Ion Boldea, "Variable speed generators", Taylor & Francis group, 2006.
6. E.W.Golding "The generation of Electricity by wind power", Redwood burn Ltd., Trowbridge, 1976.
7. S.Heir "Grid Integration of WECS", Wiley 1998

EEY 016 POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS

L	T	P	C
3	0	0	3

OBJECTIVE:

- To study about the different Renewable energy resources.
- To study about the principles involved in the conversion of renewable energy sources to electrical energy.
- To learn about the grid converters structure and control for both single-phase and three-phase systems both in power generation like PV and wind turbines connected to the grid.

1. Introduction **9**

Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (cost-GHG Emission) - Qualitative study of different renewable energy resources: Solar, wind, ocean, Biomass, Fuel cell, Hydrogen energy systems and hybrid renewable energy systems.

2. Electrical machines for Renewable Energy conversion **9**

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

3. Power converters **9**

Solar: Block diagram of solar photo voltaic system -Principle of operation: line commutated converters (inversion-mode) - Boost and buck-boost converters-selection of inverter, battery sizing, array sizing Wind: three phase AC voltage controllers- AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, Grid Interactive Inverters-matrix converters.

4. Analysis of Wind and PV systems **9**

Stand alone operation of fixed and variable speed wind energy conversion systems and solar system-Grid connection Issues -Grid integrated PMSG and SCIG Based WECS-Grid Integrated solar system

5. Hybrid Renewable Energy systems **9**

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

TOTAL: 45 hrs

REFERENCES:

1. Rashid .M. H "power electronics Hand book", Academic press, 2001.
2. Rai. G.D, "Non conventional energy sources", Khanna publishes, 1993.
3. Rai. G.D," Solar energy utilization", Khanna publishes, 1993.
4. Gray, L. Johnson, "Wind energy system", prentice hall linc, 1995.
5. Non-conventional Energy sources B.H.Khan Tata McGraw-hill Publishing Company, New Delhi.

EEY 017 APPLICATIONS OF MEMS TECHNOLOGY

L	T	P	C
3	0	0	3

OBJECTIVE:

To give an overview of MEMS including Micro-fabrication, Materials and Electromechanical concepts. Electrostatic sensors and thermal sensing are also discussed. Piezoelectric sensing and case studies involving these sensors for medical applications are covered in detail.

1. MEMS: Micro-fabrication, Materials and Electro-mechanical concepts 9

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

2. Electrostatic Sensors and Actuation 9

Principle, material, design and fabrication of parallel plate capacitors as electrostatic sensors and actuators-Applications

3. Thermal Sensing and Actuation 9

Principle, material, design and fabrication of thermal couples, thermal bimorph sensors, thermal resistor sensors-Applications.

4. Piezoelectric sensing and actuation 9

Piezoelectric effect-cantilever piezo electric actuator model-properties of piezoelectric materials-Applications.

5. CASE STUDIES 9

Piezoresistive sensors, Magnetic actuation, Micro fluidics applications, Medical applications, Optical MEMS.

TOTAL : 45 hrs

REFERENCES:

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

EE Y 018 **OUTDOOR INSULATORS** **L T P C**
3 0 0 3

Objective:

The course aims at giving a comprehensive knowledge on Outdoor Insulators, which are mainly used for Transmission and Distribution systems.

Upon completing the Course, the student will be able to do the following:

- Become familiar with different stresses encountered in the service of the insulator as well as the types and performance of Insulators.
- Able to connect the current area of Research in insulators including non-ceramic insulators
- Design and Manufacturing process of insulators can be understood
- The testing standards, selection and maintenance of insulators will also be made aware.

1. INTRODUCTION 9

Overview - Important Definitions - Types of Outdoor Insulators - Uses of Outdoor Insulators - Stresses Encountered in Service - Electrical Performance - Mechanical Performance - Role of Insulators on Overall Power System Reliability - Shapes of Outdoor Insulators - Mechanical and Electrical Ratings of Insulators - Comparison of Porcelain, Glass and Composite Insulators - Life Expectancy.

2. NONCERAMIC INSULATOR TECHNOLOGY 9

Introduction - Materials for Weathersheds / Housings - Shed Design - Insulator Core - Hardware - Establishing Equivalency to Porcelain/Glass - Manufacturing Changes and Quality Control (QC) - Un-standardization/Propagation - Live-line Maintenance Handling, Cleaning and Packaging - Brittle Fracture - Water Drop Corona - Aging and Longevity - Grading Control Rings.

3. DESIGN AND MANUFACTURE OF INSULATORS 9

Porcelain Insulators - Manufacture of Porcelain Insulators - The Porcelain Suspension Insulator - Porcelain Pin-type Insulators - Porcelain Multicone Insulators - Porcelain Long-rod and Post Insulators - Porcelain Insulators Glazes - Porcelain Insulator Hardware - Porcelain Insulator Cement - The Porcelain Dielectric.

Glass Insulators - The Glass Suspension Insulator - Glass Pin-type Insulators - Glass Multicone Post Insulators - Manufacture of Glass Insulators - Glass Insulator Hardware - Glass Insulator Cement - The Glass Dielectric.

Nonceramic Insulators - Nonceramic Suspension Insulator - Line Post Insulator - Hollow Core Insulator - Manufacture of Nonceramic Insulators - The Composite Dielectric - Voltage Stress Control.

4. TESTING STANDARDS FOR INSULATORS 9

Need for Standards - Standards Producing Organizations - Insulator Standards - Classification of Porcelain / Glass Insulator Tests - Brief Description and Philosophy of Various Tests for Cap and Pin Porcelain/Glass Insulators - Summary of Standards for Porcelain/Glass Insulators - Standards of Nonceramic (Composite) Insulators - Classification of Tests, Philosophy and Brief Description - Standards for Nonceramic Insulators.

5. SELECTION AND MAINTENANCE OF INSULATORS 9

Introduction - Cost and Weight - National Electricity Safety Code (NESC) - Basic Lightning Impulse Insulation Level (BIL) - Contamination Performance - Experience with Silicone Rubber Insulators in Salt Areas - Compaction - Grading Rings for Nonceramic Insulators.Maintenance of Insulators- Maintenance Inspection - Hotline washing - equivalent salt deposit

Total: 45 hrs

REFERENCES:

1. Ravi S. Gorur, Edward A. Cherney and Jeffrey T. Burnham, "Outdoor Insulators", Ravi S. Gorur. Inc., Phoenix, Arizona 85044, USA,1999.
2. J.S.T. Looms, "Insulators for High Voltages", Peter Peregrinus Ltd., 1988.
3. A.O. Austin, "Porcelain Insulators", Ohio Brass Company, 1980.
4. IEC 1109, "Composite Insulators for AC overhead lines with a Nominal Voltage Greater than 1000V, Definition, Test Methods and Acceptance Criteria", 1992.
5. EPRI, "Transmission Lines Reference Book - 345kV and above", 1982
6. ANSI C 29.1, "Electrical Power Insulator - Test Methods", 1992

EEY 019 POWER DISTRIBUTION SYSTEMS

L	T	P	C
3	0	0	3

COURSE OBJECTIVE:

- To design effective distribution systems to minimize voltage sag and improve the power factor closer to unity.
- To develop steady state models for analyzing distribution systems.

1. INTRODUCTION 9

General: Introduction to Distribution system, an overview of the role of computers in distribution system planning-Load modeling and characteristics: definition of basic terms like demand factor, utilization factor, load factor, plant factor, diversity factor, coincidence factor, contribution factor and loss factor-Relationship between the load factor and loss factor - Classification of loads(Residential, Commercial, Agricultural and Industrial) and their characteristics.

2. DISTRIBUTION FEEDERS AND SUBSTATIONS 9

Distribution Feeders and Substations: Design consideration of Distribution feeders: Radial and loop types of primary feeders, voltage levels, feeder-loading.

3. DESIGN PRACTICE OF THE SECONDARY DISTRIBUTION SYSTEM 9

Location of Substations: Rating of a Distribution Substation, service area with primary feeders. Benefits derived through optimal location of substations.

4. DISTRIBUTION SYSTEM ANALYSIS 9

Voltage drop and power loss calculations: Derivation for volt-drop and power loss in lines, manual methods of solution for radial networks, three-phase balanced primary lines, non-three-phase primary lines.

5. PROTECTIVE DEVICES AND COORDINATION 9

Objectives of distribution system protection, types of common faults and procedure for fault calculation. Protective Devices: Principle of operation of fuses, circuit reclosers, line sectionalizer and circuit breakers. Coordination of protective devices. General coordination procedure.

REFERENCE:

1. Turan Gonen, "Electric Power Distribution System Engineering", McGraw-Hill Book Company, 1986.
2. A.S.Pabla, Electric Power Distribution Tata Mc Graw-Hill Publishing Company, 4th edition, 1997.
3. Abdelhay A.Salam, O.P.Malik, "Electric Distribution Systems", IEEE Press,2011.

EEY 020 **SMART POWER GRID** **L T P C**
3 0 0 3

COURSE OBJECTIVE:

- Introduce the fundamentals of smart grid and associated Information technology services.
- Introduce the modelling of devices associated with smart grid.
- Introduce about the concept of wide area measuring systems (WAMS) and Phasor measurement units.

1. RECENT TRENDS IN INFORMATION &COMMUNICATION TECHNOLOGIES **9**

Distributed Services - Web Services - Creation and Deployment - Application Development Frameworks - XML-RPC - AXIS - SOAP Communication models - Service Oriented Architecture Fundamentals

2. SMART GRID FUNDAMENTALS **9**

Smart Grid Structure - Interactive Grid - Micro Grid - Distributed Resources modeling - Communication Infrastructure - Sensing and Control devices - Smart Grid characteristics

3. COMPONENTS AND STANDARDS **9**

Smart Grid Components - Metering - Virtual Power Plants - Benefits and Cost Elements - Pricing Regulations - Networking standards and Integration - Analytics.

4. AUTOMATION TECHNOLOGIES **9**

Control Centre Systems - Data Management Principles - Smart Grid Implementation standards and procedure -- Operational Issues - Modelling and Control - Advanced Metering Infrastructure - Outage Management - Distribution and Substation Automation - Customer Interactions

5. CASE STUDIES **9**

Smart Meters - Smart Grid Experimentation plan for Load Forecasting - Optimal Placement of Phasor Measurement Units (PMU) - Coordination between Cloud Computing and Smart Power Grids - Development of Power System Models and Control and Communication Software.

TOTAL: 45

REFERENCES:

1. Tony Flick and Justin Morehouse, "Securing the Smart Grid - Next Generation Power Grid Security", Elsevier Publications, 2011
2. Toby Velte, Anthony Velte and Robert C.Elsenpeter, "Cloud Computing - A Practical Approach", McGrawHill Professional edition, 2009
3. www.oe.energy.gov/DocumentsandMedia/DOE_SG_Book_Single_Pages (1).pdf
4. Mark D.Hansen, "SOA using Java Web Services", Prentice Hall Publishers, 2007
5. David A Chappell and Tyler Jewell, "Java Web Services", O`Reilly Publishers, 2002
6. Chris Thomas and Bruce Hamilton, "The Smart Grid and the Evolution of the Independent System Operator", a white paper
7. Ali Ipakchi, "Implementing the Smart Grid: Enterprise Information Integration", Grid-Interop Forum, 2007, Paper 121.122

EEY 021 HIGH VOLTAGE PULSE GENERATION, MEASUREMENT AND TESTING FOR LIFE SCIENCES

L	T	P	C
3	0	0	3

UNIT I HIGH VOLTAGE GENERATION, MEASUREMENT, TESTING 9

Generation of High Alternating Voltages – High Frequency A.C. High Voltages – Generation of Rectangular & Square Current Pulses - Measurements of High Alternating Voltages – Currents – High Power Frequency, Testing of insulators – Circuit breakers, Cables.

UNIT II NON DESTRUCTIVE TESTING TECHNIQUE 9

Measurement of Direct Current Resistivity – Dielectric constant and Loss Factor – Partial Discharge Measurement – Balance Detection Method – Calibration of Discharge Detectors – Discharge Detection in Power Cables

UNIT III BIO ELECTRICS 9

Window effect of pulsed Electric field on Biological Cells – Biological Matter due to the Application of Ultra short High Voltage Pulses – Bio response to sub Nano second ultra high voltage pulsing – Effects of Steep pulsed Electric fields on human liver cancer cells – cortical anchoring on the stability of transmembrane Electropores.

UNIT IV CANCER TREATMENT 9

Preliminary procedures – partial – mastectomy and auxiliary dissection – Total mastectomy – Reconstruction and Prosthesis – Radiation Therapy – Systemic Therapy – Complementary and Alternative Treatments

UNIT V ELECTROPORATION 9

Introduction – Effect of Electroporation – Frequency Response of Cells – Nano electroporation – Nano Second – Electroporation effects – Caspases – Calcium Bursts – Nano pulses – Nano Second pulse Generator

L= 45 Total = 45

REFERENCES:

1. E. Kuffl, W.S. Zaengl, High Voltage Engineering, Fundamentls, first Edition, 1984, PERGAMON Press, OXFORD, New York.
2. M.S. Naidu, V. Kamaraju, High Voltage Engineering, Third Edition, Tata Mc Graw Hill Publishing Company Ltd., New Delhi.

3. Chenguo Yao, Xiaoqian Hu, Yan Mi, Chengxiang Li and Caixin Sun, “Window effect of pulsed electric field on biological cells”, IEEE Trans. Dielectrics and electrical insulation Vol. 16, No. 5; October 2009, pp. 1259-1266

4. Uwe F.Pliquett and Karl. H. Schoenbach, “Changes in Electrical Impedance of Biological Matter Due to the Application of Ultrashort High Voltage Pulses”, IEEE Trans. Dielectrics and electrical insulation Vol. 16, No. 5; October 2009, pp. 1273-1279

5. R. P. Joshi, J. Song, K. H. Schoenbach and V. Sridhara, “Aspects of Lipid Membrance Bio-responses to Subnanosecond, Ultrahigh Voltage pulsing”, IEEE Trans. Dielectrics and electrical insulation Vol. 16, No. 5; October 2009, pp. 1243-1250

6. Yan Mi, Chengxiang Li, Caixin Sun, Liling Tang and Huan Liu, “Apoptosis Induction Effects of Steep Pulsed Electric Fields (SPEF) on Human Liver Cancer Cell SMMC-7721 in vitro”, IEEE Trans. Dielectrics and electrical insulation Vol. 16, No. 5; October 2009, pp. 1302-1310

7. S. M. Kennedy, Z. Ji, N. B. Rockweiler, A. R. Hahn, J. H. Booske and S. C.Hagness, “The Role of Plasmalemmal-Cortical Anchoring on the Stability of Transmembrane Electropres”, IEEE Trans. Dielectrics and electrical insulation Vol. 16, No. 5; October 2009, pp. 1251-1258

8. Raji Sundararajan, Nano Second Electroporation Another look Mol Biotechnol (2009) 41:69-82

9. Susan M. Love, Karen Lindsey, Dr. Susan Love’s Breast Book, 4th Edition, First Da Ca Po Press Edition, 2005

EEY 041 AUTOMOTIVE INFOTAINMENT SYSTEMS

L	T	P	C
3	0	0	3

UNIT 1 FUNDAMENTALS OF AUTOMOTIVE ELECTRICAL SYSTEMS 9

Batteries – Types, Use and Maintenance, Failures, Construction, Performance characteristics – battery rating capacity – Battery Testing –electric power steering.

UNIT 2 FUNDAMENTALS OF AUTOMOTIVE ELECTRONIC SYSTEMS 9

Automotive chassis system – automotive microprocessor uses – electronic dash board instruments – onboard diagnosis system –electronic control of braking and traction - automatic transmission, electronic clutch.

UNIT 3 IGNITION SYSTEMS 9

Types of solid state ignition systems and their principle of operation, advantages of electronic ignition systems, contactless electronic ignition system, distributor-less ignition, electronic sparks timing and control, spark arrester, throttle body injection and multi port or point fuel injection.

UNIT 4 INFOTAINMENT SYSTEMS 9

Types of AI systems, Different OEMs, Features – Single / Dual Tuner, CD, CDDA, Aux, Traffic Announcements, News, Alarm, Parking Aid Control, Touch Screen displays, Diagnostics, Network Management

UNIT 5 POWER FLUCTUATIONS IN CAR 9

Power drop-out, Crank drop-out, Slow recovery waveforms, Programmable Power Supply related crank generation, CI Test Jig, Ford EMC spec, Fiat EMC Specs.

TEXT BOOK

1. Judge, A., W., Modern Electrical Equipment of Automobiles, Chapman and Hall, London, 1992.

REFERENCES

1. Young, A. P. and Griffiths, L., Automobile Electrical Equipment, English Languages Book Society and New Press, 1990.
2. Vinal, G. W., Storage batteries, John Wiley and Sons Inc. New York, 1985

3. Crouse, W. H., Automobile Electrical Equipment, McGraw Hill Book Co. Inc. New York, 1980.

4. Spread Bury, F. G., Electrical Ignition Equipment, Constable and Co. Ltd., London, 1962.

5. Kholi, P. L., Automotive Electrical Equipment, Tata McGraw-Hill Co Ltd, New Delhi, 1975.

EE 624 ANALYSIS OF INVERTERS

L	T	P	C
3	0	0	3

OBJECTIVE:

The main objective of the course is to make a simulation study of three phase single level and multi level Inverters. Three phase systems with nonlinear loads are modeled and their characteristics is observed. Active power filters can be modeled with Inverters and suitable switching control strategies to carry out harmonic elimination.

1. SINGLE PHASE INVERTERS 12

Introduction to self commutated switches: MOSFET and IGBT - Principle of operation of half and full bridge inverters - Performance parameters - Voltage control of single phase inverters using various PWM techniques - various harmonic elimination techniques

2. THREE PHASE VOLTAGE SOURCE INVERTERS 9

180 degree and 120 degree conduction mode inverters with star and delta connected loads - voltage control of three phase inverters: single, multi pulse, sinusoidal, space vector modulation techniques.

3. CURRENT SOURCE INVERTERS 9

Operation of six-step thyristor inverter - inverter operation modes - load - commutated inverters - Auto sequential current source inverter (ASCI) - current pulsations - comparison of current source inverter and voltage source inverters

4. MULTILEVEL INVERTERS 9

Multilevel concept - diode clamped - flying capacitor - cascade type multilevel inverters - Comparison of multilevel inverters - application of multilevel inverters.

5. RESONANT INVERTERS 6

Series and parallel resonant inverters - voltage control of resonant inverters - Class E resonant inverter - resonant DC - link inverters.

TOTAL: 45 hrs

TEXT BOOKS:

1. Rashid M.H., "Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Third Edition, New Delhi, 2004.

2. Jai P.Agrawal, "Power Electronics Systems", Pearson Education, Second Edition, 2002.

3. Bimal K.Bose "Modern Power Electronics and AC Drives", Pearson Education, Second Edition, 2003.

4. Ned Mohan, Undeland and Robbin, "Power Electronics: converters, Application and design" John Wiley and sons.Inc, Newyork, 1995.

5. Philip T. krein, "Elements of Power Electronics" Oxford University Press - 1998.

REFERENCES:

1. P.C. Sen, "Modern Power Electronics", Wheeler Publishing Co, First Edition, New Delhi, 1998.

2. P.S.Bimbra, "Power Electronics", Khanna Publishers, Eleventh Edition, 2003.

CSY 098 SOFT COMPUTING TECHNIQUES

L	T	P	C
3	0	0	3

OBJECTIVE:

To expose the students to various Artificial Intelligence techniques like Symbolic reasoning, rule-based systems etc. To expose the students to various Artificial Neural networks models like Adaline, Madaline, Hopfield network etc. Various fuzzy logic systems and applications are also discussed. Genetic Algorithm and other applications for GA techniques are studied.

1. INTRODUCTION 9

Approaches to intelligent control. Architecture for intelligent control. Symbolic reasoning system, rule-based systems, the AI approach. Knowledge representation. Expert systems.

2. ARTIFICIAL NEURAL NETWORKS 9

Concept of Artificial Neural Networks and its basic mathematical model, McCulloch-Pitts neuron model, simple perceptron, Adaline and Madaline, Feed-forward Multilayer Perceptron. Learning and Training the neural network. Hopfield network,. Application of neural networks to load forecasting and Control.

3. FUZZY LOGIC SYSTEM 9

Introduction to crisp sets and fuzzy sets, basic fuzzy set operation and approximate reasoning. Introduction to fuzzy logic modelling and control. Fuzzification, inferencing and defuzzification. Fuzzy knowledge and rule bases. -Fuzzy Logic based power system stabilizer.

4. GENETIC ALGORITHM 9

Basic concept of Genetic algorithm and detail algorithmic steps, adjustment of free parameters. Solution of typical control problems using genetic algorithm.

5. APPLICATIONS 9

GA application to power system optimization problem, Case studies: Identification and control of linear and nonlinear dynamic systems using Matlab-Neural Network toolbox.. Implementation of fuzzy logic controller using Matlab fuzzy-logic toolbox.

TOTAL: 45 hrs

REFERENCES:

1. Jacek.M.Zurada, "Introduction to Artificial Neural Systems", Jaico Publishing House, 1999.

2. KOSKO, B. "Neural Networks and Fuzzy Systems", Prentice-Hall of India Pvt. Ltd., 1994.

3. KLIR G.J. & FOLGER T.A. "Fuzzy sets, uncertainty and Information", Prentice-Hall of India Pvt. Ltd., 1993.

4. Zimmerman H.J. "Fuzzy set theory-and its Applications"-Kluwer Academic Publishers, 1994.

5. Driankov, Hellendroon, "Introduction to Fuzzy Control", Narosa Publishers.

MEY 012	RESEARCH METHODOLOGY	L T P C
		3 0 0 3

OBJECTIVE:

The aim of the course is to introduce scholars to a number of perspectives on research and to broaden their conceptions of what research involves. This course covers research design, information retrieval, problem formulation, use of statistical techniques, evaluation and writing of research reports, papers and ethics in research.

1 Research problem formulation **7**

Research - objectives - types, Research process, solving engineering problems Identification of research topic - formulation of research problem, literature survey and review.

2 Research Design **8**

Research design - meaning and need - basic concepts - Different research designs, Experimental design - principle - important experimental designs, Design of experimental setup, Mathematical modeling - Simulation - validation and experimentation, Dimensional analysis - similitude.

3 Use of statistical tools in research **12**

Importance of statistics in research - concept of probability - popular distributions - sample design. Hypothesis testing, ANOVA, Design of experiments - factorial designs - orthogonal arrays, Multivariate analysis - correlation and regression, Curve fitting.

4 Analysis and Interpretation of Data **10**

Research Data analysis - interpretation of results- correlation with scientific facts - repeatability and reproducibility of results - accuracy and precision - limitations, Use of optimization techniques - Traditional methods - evolutionary optimization techniques.

5 The Research Report **8**

Purpose of written report - audience - synopsis writing - preparing papers for International Journals, Thesis writing - organization of contents - style of writing - graphs and charts - referencing, Oral presentation and defence, Ethics in research, Patenting, IPR.

Total: 45 hrs

REFERENCES:

1. Kothari C.R., Research, Methodology - Method and Techniques. New Age International (P) Ltd., New Delhi, Reprint 2003.
2. Doebelin, Ernest O., Engineering Experimentation: planning, execution, reporting, McGraw - Hill International International edition, 1995
3. George E. Dieter., Engineering Design, McGraw Hill - International edition, 2000
4. Rao S.S. Engineering Optimization - theory and Practice, New Age International (P) New Delhi, reprint
5. Madhav S. Phadke, Quality Engineering using Robust Design, Printice Hall, Eaglewood Cliffs, New Jersey, 1989.
6. Dan Jones, Technical writing style, Pearson Education Company, Massachusetts, 1998
7. Abdul Rahim R., Thesis writing: A Manual for Researchers, New Age International (P) Ltd., 1996.