ELECTRICAL ENGINEERING

Final Year B. Tech.
Effective from A. Y. 2018-19

INDEX

List of Abbreviations

Sr. No.	Abbreviation	Stands for:
1	DEC	Departmental Elective Course
2	PSC	Professional Science Course
3	PCC	Program Core Course
4	LC	Laboratory Course
5	HSSC	Humanities and Social Science Course
6	MLC	Mandatory Learning Course
8	LLC	Liberal Learning Course
9	BSC	Basic Science Course

Program Education Objectives (PEOs):

1. To produce around 75 electrical graduates annually who, immediately following graduation, are employable in the diversified sectors of the industry, government organizations, public sector and multinational corporations and/or pursue higher Educational in electrical or other fields of their interests, at institutes of repute and high standard.

2. To prepare graduates who demonstrate measurable progress in the fields they choose to pursue.

3. To prepare graduates, who are able to communicate effectively, adopt lifelong learning, act with integrity and have inter-personal skills needed to engage in, lead and nurture diverse teams, with commitment to their ethical and social responsibilities.

Program Outcomes (POs):

On successful completion Graduates will demonstrate:

a. Knowledge of science, mathematics, and engineering principles.

b. Ability to apply this knowledge of science, mathematics, and engineering principles for solving problems.

c. Ability to identify, formulate and solve electrical engineering problems in the broad areas like electrical machines, analog and digital electronics, power systems and control systems.

d. Ability to understand and use different software tools in the domain of circuit, field, power system, control system simulations.

e. Ability to design and conduct experiments and analyze and interpret data.

f. Ability to function as a member of a multidisciplinary team.

g. Demonstrated sensitivity towards professional and ethical responsibility.

h. Ability to communicate effectively in writing as well as through public speaking.

i. Demonstrated ability to appreciate and engage in lifelong learning.

j. Demonstrated knowledge of contemporary issues.

k. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

l. The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.

B.TECH. RULES and REGULATIONS

For the Award of B. Tech. Degree
(Applicable from the academic year 2013-14)

1. **Short Title and Commencement:**

(a) These Regulations shall be called the "College of Engineering, Pune Regulations for the Award of B. Tech. Degree".

(b) They shall come into effect from the date of getting approval from the Board of Governors of the College.

(c) They shall be applicable for all students enrolling for B. Tech. Degree programmes at the College from Academic year 2013-14.

2. **Definitions:**

(a) "B. Tech." means Bachelor of Technology, an Under Graduate Degree awarded from the University;

(b) "Board" means Board of Governors of the college;

(c) "College" means College of Engineering, Pune;

(e) "Dean" means Dean of the College, with the specific functions also indicated along with the title;

(g) "Director" means Director of the College;

(h) "Government" means Government of the Maharashtra;

(j) "Regulations" means College of Engineering, Pune Regulations for the Award of B. Tech. Degree;

(k) "Senate" means Senate of the College;

(l) "University" means University of Pune;

3. **Preamble:**

The Regulations prescribed herein have been made by the College, an autonomous institution under the University, to facilitate the smooth and orderly conduct of its academic programmes and activities at the B. Tech level. It is expected that the Regulations will enable the students to take advantage of the various academic opportunities at the College and prepare themselves to face the challenges in their professional careers ahead. It may be noted that:

(a) The provisions made herein shall be applicable to all the B. Tech. Programmes offered at the College, at present;

(b) They shall also be applicable to all the new B. Tech. Programmes which may be started at the College in the future;

(c) Academic and non-academic requirements prescribed by the Senate have to be fulfilled by a student for eligibility to the B. Tech. Award;

4. Academic Calendar:

Table 1: Suggested Breakdown of Academic Year into Semesters

1. No. of Semesters/ Year	Three; Two being Main Semesters (Odd and Even) and One being a Supplementary Semester; (Note: Supplementary Semester is primarily to assist weak and/or failed students through make up courses, wherever possible. However, the College may use this Semester to arrange Add-On Courses for other students and/or for deputing them for practical training elsewhere.)
2. Semester Durations:	Main Semesters: 19 Weeks each; Supplementary Semester: 8 Weeks;
3. Academic Activities (Weeks):	Main Semester (Odd or Even) Registration of Courses- 0.5; Course work- 15.5; Examination Preparation-1.0; Examinations- 1.0; Declaration of Results- 1.0; Total: 19; Supplementary Semester (only for makeup Courses): Registration of Courses- 0.1; Course Work- 7.0; Examination Preparation-0.2; Examinations- 0.2; Declaration of Results- 0.5; Total: 8; Inter-Semester Recess: After each Main Semester- 2; After Supplementary Semester- 2; Total: 14 (for good students) and 6 (for weak students) *(Note: In each Semester, there shall be provision for students for Registration of Courses at the beginning, Dropping of Courses in the middle under the advice of Faculty Members and approved by Departmental Undergraduate Programme Committee (DUPC).*

4. Examinations:	Continuous Internal Evaluation (CIE) and Semester End Examination (ESE), both having weightage in the students' performance in Course Work/Laboratory Work and other activities; (Note: The CIE shall be conducted throughout the Semester on dates announced in advance and its results made known to the students from time to time. This would be of help to the students to decide on Dropping or Withdrawal from Courses in consultation with their Advisors. However, the dates for the ESE shall be fixed at the College level.
5. Other Items:	• Care shall be taken to ensure that the total number of days for academic work are > 180/year; • Academic schedules prescribed shall be strictly adhered to by all the Departments; • Supplementary Semester shall be mainly for Make up Courses, to benefit weak or failed students to the extent possible; • Students failed in a course after re-examination shall attend a Course fully when it is offered again, and appear for all components of evaluation; • Specified Min. /Max. Course load per Semester shall be followed at all times.

(a) Each academic year shall be divided into two main semesters, each of 19 weeks, viz., odd semester (Jul. – Dec.) and even semester (Dec. – Apr.), and an 8- week supplementary semester (Apr.-Jun.).

(b) The College shall arrange regular academic activities for the students during the two main semesters and makeup and other courses for the students during the supplementary semester;

(c) The academic activities in a semester shall normally include course registration, course work, continuous internal evaluation, dropping/withdrawal from courses, semester-end examination, and declaration of results.

(d) The College shall announce the schedule for all the academic activities well before the commencement of the academic year and take all the necessary steps to follow them scrupulously.

(e) The college shall also announce adequate intra-semester and inter-semester breaks for the students and ensure that a minimum of 180 academic working days are available during the academic year.

(f) A typical breakdown of the academic year for the B. Tech programme at the College shall be as suggested in Table 1.

5. **Admissions:**

(a) The intake capacity of each programme, including the number of seats to be reserved for students of different categories shall be decided by the Board by following the Government directives and Council approvals.

(b) Admissions to the first year of all the programmes shall be made before the start of each academic year, through the Maharashtra Combined Entrance Test (MHCET) conducted by the Government.

(c) The College shall also admit to first year of the programmes, a limited number of students of Non-Resident Indian (NRI), Persons of Indian Origin (PIO) and Foreign National categories, as per Government rules.

(d) There shall also be a merit-based, lateral admission of students having Diploma qualification to the second year of all the programmes at the College in accordance with the Government rules applicable for such admissions.

(e) The College reserves the right to revoke the admission made to a candidate, if it is found at any time after admission that he/she does not fulfill all the requirements stipulated in the offer of admission.

(f) The College also reserves the right to cancel the admission of any student and discontinue his/her studies at any stage of studentship for unsatisfactory academic performance and/or undisciplined conduct.

6. **Residence:**

(a) Interested students may apply for hostel accommodation at the time of admissions, as the College is partially residential and it can admit a limited number of men and women students in the hostels.

(b) The method of admission to students' hostels, rent payable per each seat allotted and the discipline to be followed by the residents shall be governed by "rules and regulations" framed by the College in this behalf.

(c) Each student selected for hostel admission shall be provided a seat in one of the hostel rooms identified for this purpose and there shall be no family accommodation available in the hostel for married students.

(d) Students residing in the hostels shall adhere to the prescribed hostel discipline and pay the hostel/mess charges regularly, as any failure to do so, may lead to withdrawal of hostel facilities to such students.

(e) Hostel residents shall apply for leave of absence and get the same approved before leaving the hostel even for a few days, as any failure to do so may lead to cancellation of hostel admission to such students.

(f) Students residing in the hostels shall be required to clear all the hostel dues and

vacate their rooms at the end of each academic year, as they will be considered for hostel admission afresh for the New Year.

7. **Attendance:**

(a) Each student shall be required to attend at least 75 per cent of all the classes arranged like, lectures, tutorials, laboratories, studios and workshops for being permitted to attend the semester-end examination.

(b) Extra Academic Activities (EAC) like Yoga, NSS, Physical Training, NCC and, Boat Club shall be compulsory for students of the first year, with at least a minimum attendance of 75 percent in each of them.

(c) Students shall also be required to take part in any other academic and non- academic activities and attend the camps, as and when arranged by the College during the academic year.

(d) Students desirous of leave of absence for less than two weeks during a semester shall apply for it in advance to the Head of the Department giving reasons & supporting documents, if any and get it approved.

(e) Absence due to illness or any other reason for a period less than two weeks in a semester, for which a student could not make prior application, may be condoned by the Head of the Department after proper verification.

(f) The Dean, Academic Affairs shall be the Authority for sanctioning the leave of students outside clauses (4) and (5) above, after receiving their applications along with recommendations of the Heads of Departments.

(g) In the case of long absence of a student in a semester with prior approval or otherwise, the Dean, Academic Affairs shall decide whether the student be asked to withdraw from the programme for that particular semester.

(h) In all the cases of leave of absence as per Clauses (4)-(6) above, the period of leave taken shall not be condoned for the purposes of fulfilling the attendance requirements stipulated in the Clauses (1) and (2).

(i) It shall be the responsibility of a student residing in the hostel to intimate the Warden of his/her hostel and also the concerned course instructors regarding his/her absence before proceeding on leave.

8. **Conduct and Discipline:**

(a) All students shall be required to conduct themselves in a manner befitting the students of a national institution of high reputation, within and outside the precincts of the College.

(b) Unsocial activities like ragging in any form shall not be permitted within or outside the precincts of the College and the students found indulging in them shall be dealt with severely and dismissed from the College.

(c) The following additional acts of omission and/or commission by the

students within or outside the precincts of the College shall constitute gross violation of code of conduct punishable as indiscipline:

i. Lack of courtesy and decorum, as well as indecent behaviour;
ii. Willful damage of property of the College/Hostel or of fellow students;
iii. Possession/consumption/distribution of alcoholic drinks and banned drugs;
iv. Mutilation or unauthorized possession of library material, like books;
v. Noisy and unseemly behaviour, disturbing peace in the College/Hostel;
vi. Hacking in computer systems, either hardware or software or both;
vii. Any other act considered by the College as of gross indiscipline.

(d) In each case above, the punishment shall be based on the gravity of offence, covering from reprimand, levy of fine, expulsion from Hostel, debar from examination, rustication for a period, to outright expulsion.

(e) The reprimanding Authority for an offence committed by students in the Hostels and in the Department or the classroom shall be respectively, the Rector of the Hostels and the Head of the concerned Department.

(f) In all the cases of offence committed by students in jurisdictions outside the purview of Clause (5), the Dean, Students Affairs shall be the Authority to reprimand them.

(g) All major acts of indiscipline involving punishment other than mere reprimand, shall be considered and decided by the Chairman, Students Disciplinary Committee appointed by the Senate.

(h) All other cases of indiscipline of students, like adoption of unfair means in the examinations shall be reported to the Dean, Academic Affairs, for taking appropriate action and deciding on the punishment to be levied.

(i) In all the cases of punishment levied on the students for any offence committed, the aggrieved party shall have the right to appeal to the Director, who shall constitute appropriate Committees to review the case.

9. **Change of Branch:**

(a) Change of branch shall be permissible for a limited number of special cases in the third semester as per following regulations.

(b) Only those students who have completed the common credits required in the first two semesters in their first attempt with a minimum CGPA of 8.5 shall only be eligible for making application for a change of branch. The students whose admission is based on Tuition Fee Waiver Scheme, PIO's, and BTech. Planning are not allowed for the branch change.

(c) There shall be a maximum number of only two students admitted in any discipline in the third semester through the branch change rule.

(d) Intending students eligible for change of branch shall apply for the same to

the Office of Academic Affairs of the College before the closing date notified at the beginning of odd semester of each academic year.

(e) Such students shall be required to indicate up to three branches, in order of preference to which they wish to change over, as the change shall be strictly based on their merit, subject to availability of vacancies.

(f) The change of branch shall be permitted purely on inter-se merit of all the eligible applicants. The CGPA of students at the end of the second semester shall be considered for rank ordering of the applicants seeking change of branch and in the case of a tie, the MHCET ranks shall also be considered.

(g) All the changes of branch permitted for intending students as per the above clauses shall be effective from their third semester only and no further change of branch shall be permitted after this.

(h) All the changes of branch permitted at this stage shall be final and binding on the applicants and no student shall be permitted, under any circumstances, to refuse the change of branch offered.

(i) The candidates who have sought admission under Tuition Fee Waiver Scheme are not eligible for the branch change.

10. **Course Structure:**

a) Each course offered in the B. Tech. curriculum at the College shall be listed by using a total of five/six digits, the first two being letters and the remaining being numerals, as follows:

i. The first two letters to represent the Department offering the Course in abbreviated form, e.g., CE for Civil Engineering;

ii. The first numeral that follows to represent the year of the programme, such as 1, 2, 3 and 4, leading to 100,- 400 series;

iii. The next two numerals to represent the Course Number allotted for the subject by the Department, i.e., 01, 02, 03, up to 99;

iv. Thus, as an example, courses offered at the Department of Civil Engineering could be listed from CE 101 up to CE 499 or based on the automated subject numbering system implemented in MIS;

b) All the courses in the B. Tech. Curriculum shall be unitized, with one credit being assigned to each unit of course work, after the student completes its teaching-learning process successfully.

c) The assignment of credits to course work shall follow the well accepted practice at leading institutions, with one credit being defined to mean:

1. Lecture course conducted for one hour per week in a semester;

2. Tutorial conducted for one hour per week in a semester;

3. Laboratory/Practical conducted for two/three hours per week in a semester;

4. Project work conducted for two hours per week in a semester;

d) Each student for the B. Tech, Degree award shall be required to earn a total of

180 credits during his/her studentship at the College. While a student can register for more than 180 credits at the College, only 180 credits shall be reckoned for the Degree award. On the other hand, a student having less than 180 credits shall have to earn the remaining credits to make up the total to 180 credits so as to qualify for the Degree award. The total number of credits earned to complete the course depends on the academic schema for which the student has enrolled for.

e) In addition to the credit requirement prescribed above for the Degree award, each

student shall have to complete the requirements of Extra Academic Activities (EAA) as referred to earlier in Clause 2 of Section 7, during the first two semesters of the programme. All the students shall receive certification as PP (for Passed), and NP (for not passed) in EAA, in the Grade Card. While obtaining certification as PP is a mandatory requirement for the Degree award of a student, this shall not be taken into account for computing the final Grade Point Average.

1. Each student shall register for an average of 22 credits per semester during his/her studentship at the College, with the minimum and maximum credits being fixed as 16 and 28 credits per semester respectively. The exact number of credits to be registered by a student in a semester in a particular Department shall be decided by his/her Faculty Advisor based on the student's academic performance in the preceding semester and approval by the Departmental Undergraduate Programme Committee (DUPC).
2. The medium of instruction for course work and examinations at the College shall be English.The course work for the Programme shall be broady divided into six main subject groups, as follows:
    - Humanities & Social Sciences;
    - Professional Science Courses
    - Basic Sciences including Mathematics;
    - Basic Engineering Sciences & Practice;
    - Professional Subjects;
    - Liberal Learning Courses
3. The total course package for the Programme at a Department shall have the following components:
    - Institutional Core subjects
    - Departmental Core subjects
    - Departmental Elective subjects
    - Other Elective subjects

f) The DUPC shall be responsible for planning the curriculum and syllabi for

all the courses included for the Programme for approval by the Senate However, the Institutional Undergraduate Programme Committee (IUPC) shall be in charge for College wide implementation of course work, time tables and related requirements for the Programme.

g) Each Department shall have the flexibility to include industrial training and/or field work of 8 weeks for all its students as a compulsory requirement for the Degree award and this can be assigned credits, as approved by the Senate. However, these shall be arranged during the supplementary semester period following the sixth semester of studies at the College.

h) Each Department shall assign Faculty Advisors for all its students in consultation with the Dean, Academic Affairs and Dean, Students Affairs. It shall be the responsibility of the Faculty Advisors to help the students in planning their course work and other academic activities at the Department and also to regularly monitor and advise them on their academic and other performance at the College. For students of the first two semesters in any Department, the Dean, Students Affairs may assign Faculty Advisors from among the faculty of Basic Science including Mathematics and HSS Departments.

11. **Registration of Courses:**

(a) Each student shall be required to register for course work by following the advice of the Faculty Advisor at the commencement of each semester on the day fixed for such registration and notified in the Academic Calendar.

(b) Students who fail to register for course work on the notified day may be permitted by the Department for late registration on another day announced in the Academic Calendar after payment of an additional fee fixed by the College.

(c) Only those students shall be permitted to register for course work who have:

i. Cleared all dues of the College, Hostel and Library including fines (if any) of the previous semester,

ii. Made all the required advance payments towards the College and Hostel dues for the current semester before the closing date, and

iii. Not been debarred from registration of courses on any other specific ground. (d) Each student shall fulfill the following conditions at the time of registration of course work in any semester:

i. Each student of the first year shall register for all the courses in the first two semesters, with flexibility to drop one/two courses up to the minimum permissible limit of 18 credits in each case. Similarly Direct Diploma students will also register for all courses in third and fourth semester.

ii. A student shall be permitted to register for more than the average course load, i.e., up to a maximum of 28 credits, if he/she hasshown outstanding performance in course work in the previous semesters, i.e., CGPA>=8.0.

iii. On the other hand, a student whose performance is not so good in the preceding semesters, i. e., =<5.0, shall be permitted to register 18 credits, the students who have secured CGPA in between 5 and 6 are allowed for normal credits (i.e. The credits offered by the department in that semester) and the students who have secured more than 6 CGPA are allowed to register for one additional course. The students are mandatorily required to register for backlog subjects first. The faculty advisor is required to check for the pre-requisites if any at the time of registration.

iv. Students having CGPA less than 5 at the time of admission to 7th Semester, shall not be allowed to register for the next year subjects / project work till their CGPA/SGPA improves above 5 respectively.

- In case of student clearing all subjects till sixth semester of B. Tech with CGPA < 5, he/she will be allowed for grade improvement in odd semester of final year.
- For grade improvement, student will have to take 3 subjects in which he/she has secured DD or CD grades from the same semester in one stretch.
- Student can choose three subjects from a particular semester offered for T.Y B.Tech (odd semester) in which he/she has secured DD or CD grade. Student will have to register for these subjects in VII semester in which

  those subjects are offered. He/she will not be allowed to take up project work.
- In such cases if student improves his/her CGPA he/she will be allowed to register as a special case, for the project work in odd/even semester of Final Year of B. Tech.

(e) All the students shall note the following special features of the credit system, which shall be strictly followed at the College:

i. ESE shall be conducted for the course once in a semester, except to meet the needs of students specially permitted by the College.

ii. A student shall have to re-register in all the failed courses (i.e., Getting Grade FF after summer term/re-examination) at any further semester when they are offered again, freedom being given to the student to change the course only if it is an elective.

iii. Also, a student getting certification as NP in the Extra Academic Activities (EAC), shall re- register for them in a following semester/s until he/she obtains certification as PP.

(f) A student shall have the possibility to drop a course in the middle of a semester as per the Academic Calendar, without mention in the Grade Card, with the concurrence of the Faculty Advisor, and after intimating the concerned course instructor/s and the academic section. However, it shall not be possible for a student to register for an alternative course in that semester.

12. **Supplementary Semester:**

(a) Departments shall have the flexibility to conduct supplementary semesters for **FY BTech. courses** only during summer months, as per the Academic Calendar. Such a semester shall be offered on the recommendation of DUPC and with the approval of the Dean, Academic Affairs. A student shall be allowed to register for a maximum of three subjects in a supplementary semester. There is re-examination for the FY BTech. Students. No summer term or re-examination will be floated for the laboratory courses.

(b) The supplementary semester shall be utilized primarily to facilitate the failed students to attend the courses in which they have failed and not for launching any new courses for credit. However, a Department shall be free to arrange any Add- On courses for its students during this semester.

(c) The academic activity in the supplementary semester shall be at double the rate as compared to a normal semester; e.g., 1 credit of course work shall require two hours/week in the class room, so that the contact hours are maintained the same as in a normal semester. It shall also be necessary to fulfill the requirements of CIE and ESE for all the courses like in a normal semester.

(d) Courses planned for the supplementary semester shall be announced by the Dean, Academic Affairs in each year, well before the conclusion of the even semester. Students intending to avail of this facility shall have to register for the courses offered by paying the prescribed fees within the stipulated time.

(e) It shall be the responsibility of the Department to plan in advance the faculty and non-teaching staff requirements to conduct the supplementary semester and take necessary steps including the institutional approvals for organizing the same.

(g) The student who are either dropped or detained in the course/s during regular semester is not allowed to register for that course/s in summer.

(h) Re-exam (ONLY for 60 marks equivalent to end semester exam) shall be conducted for all other classes three weeks after grade approval by DUPC. The re exam shall be conducted after every semester, for all subjects offered in that semester. For final grading, T1, T2 scores of respective semester shall be

used. Grade ranges shall be same as that of regular semester for that subject.

(i) The students those who have passed in the re-examination will be awarded grade report with * marked on the subjects passed in re-examination.

13. **Programme Duration:**

(a) The Programme duration for a student to complete the academic and other requirements at the College and qualify for the award of Degree by the University shall be normally 8 semesters.

(b) However, it shall be possible for an outstanding student to qualify for the Degree award in less than eight semesters, by registering for more number of credits i.e., up to the maximum permissible limit of 28 credits per semester from the third semester onwards to complete the Programme requirements of 180 credits. In such a case, the College shall issue a Provisional Certificate to the student who shall await the completion of eight semesters for the Degree award by the University.

(c) This flexibility shall also enable academically weaker students to conduct their studies at a slower pace and complete their Degree requirements in more than eight semesters. The maximum duration for the course completion will be 12 semesters.

(d) Clause (3) above shall be applicable to two types of students at the College:

i. Those wishing to complete the Degree requirements comfortably without encountering failure in any course;

(e) In both the above cases, a student shall have to complete the Programme requirements for the Degree of 180 credits within 12 semesters. Failure to complete the Programme requirements by any student in this period shall lead to the cancellation of his/her admission to the College forthwith. The Senate on case to case basis on the recommendations of the Director and Dean-Academics can extend the term.

(f) A student will not be awarded degree if his/her CGPA at the end of the course is less than 5. For such students the performance improvement scheme is recommended wherein he/she is eligible to take any three subjects for the improvement.

14. **Temporary Withdrawal**:

(a) Student shall be permitted to withdraw temporarily from the College on the grounds like prolonged illness, grave calamity in the family or any other serious happening. The withdrawal shall be for periods which are integral

multiples of a semester, provided that

i. He/She applies to the College within at least 6 weeks of the commencement of the semester or from the date he/she last attended the classes, whichever is later, stating fully the reasons for such withdrawal together with supporting documents and endorsement of his/her guardian.

ii. The College is satisfied that, even by taking into account the expected period of withdrawal, the student has the possibility to complete the Programme requirements of 180 credits within the time limits specified earlier.

iii. The student shall have settled all the dues or demands at the College including those of Hostel, Department, Library and other units.

(b) A student availing of temporary withdrawal from the College under the above provision shall be required to pay such fees and/or charges as may be fixed by the College until such time as the students name appears on the Roll List. However, it shall be noted that the fees/charges once paid shall not be refunded.

(c) Normally, a student shall be entitled to avail of the temporary withdrawal facility only once during his/her studentship of the Programme at the College.

15. **Termination from the Programme**:

A student shall be required to leave the College on the following grounds

i. Absence from classes for more than six weeks at a time in a semester without leave of absence being approved by the competent authorities, shall result in the student's name being struck off the College rolls.

ii. Failure to meet the standards of discipline as prescribed by the College from time to time shall also result in the student being recommended by the Students Disciplinary Committee to leave the College.

16. **Performance Assessment**:

(a) There shall be achievement testing of all the students attending a course, like lecture course, laboratory/design/drawing course or a combination of the two. This shall be in two parts, as follows, both of them being important in assessing the students performance and achievement in the particular course:

1. Sessional, involving Continuous Internal Evaluation (CIE), to be normally conducted by the subject teacher all through the semester; This shall include mid-term tests, weekly/fortnightly class tests, home work assignments, problem solving, group discussions, quiz, seminar, mini-project and other means. The subject teacher shall announce the detailed methodology for conducting the various segments of CIE together with

their weightages at the beginning of the semester.

2. Terminal, often designated as End Semester- Examination (ESE), to be conducted by the subject teacher, preferably jointly with an external examiner; This shall include a written examination for theory courses and practical/design/drawing examination with built-in oral part for laboratory/ design/drawing courses.
3. CIE and ESE shall have 40:60 weightage. A student's performance in a subject shall be judged by taking into account the results of CIE and ESE together.

- From the Academic Year 2013-14 there will be only two continuous evaluation examinations and ESE. The weightage for these evaluations will be T1 (20%), T2 (20%) and End-Semester (60%). Dean academics will declare the tentative schedule of these examinations in the academic calendar. Exact dates for ESE and common subjects/Open electives for T1 and T2 will be declared by Controller of Examination in consultation with Dean Academics. The administration of T1 and T2 (except common subjects/Open electives) will be at department level.
- In case of absentee for T1, T2, and End-Semester Examination, student will have to seek permission of Dean Academics to appear for Re-examination. This permission will not be a privilege and will be decided on a case to case basis. If any student participates in any of the events on behalf of the institute, he/she will inform in advance in writing to Dean Academics with recommendation from Dean Students Affairs.
- If any of the students misses T-1 or T-2 for genuine reasons and re-examination is not to be conducted, then his/her end-Semester performance will be appropriately weighted to account for the loss of T-1 or T-2. If any student misses both T-1 and T-2 then no proportionate ratification in marks will be done and his marks in end-semester examination will be considered for final grades.
- Legitimate reasons for re-examination will be as follows:

  Illness on or immediately before the exam date (may include the critical illness of a close family member); bereavement i.e. death of someone in a close relationship with the student; or a sufficiently crowded exam schedule (technically, 3 or more End Sem exams in one day).

4. The evaluation of the project work shall be based on Sessional Work assigned by the project supervisor, seminar presentation, project report and assessment by Project Evaluation Committee, as covered in Clause(7) later in this Section.
5. In the case of other requirements, such as, seminar, comprehensive viva

voce and EAA the assessment shall be made as determined by the Grade Awarding Authority of the College.

6. While the conduct of CIE for a course shall be the responsibility of the subject teacher and the Department concerned, and ESE shall be conducted centrally by the Examination Section of the College. The records of both CIE and ESE shall be maintained by the Examination Section.
7. The performance of students at every stage of the CIE shall be announced by the concerned subject teacher within a fortnight of the date of the particular assessment. The subject teacher shall also show the assessed answer books to the students before submission of the final marks to the Controller of Examinations.
8. The concerned subject teacher shall also be responsible to award letter grades to the students after the ESE is completed and to submit the final results of the course within one week of the last date of ESE to the Controller of Examinations through the Head of his/her Department.

(b) Question Papers: For being able to conduct achievement testing of the students in an effective manner, good question papers shall be used as the principal tool, making it necessary for the question papers at CIE and ESE to:

i. Cover all sections of the course syllabus uniformly;
ii. Be unambiguous and free from any defects/errors;
iii. Emphasize knowledge testing, problem solving & quantitative methods;
iv. Contain adequate data/ other information on the problems assigned;
v. Have clear and complete instructions to the candidates.

(c) Therefore, the question papers, particularly at ESE, shall be set covering the entire syllabus and the students given opportunity to answer questions from the full syllabus of the course by restricting their choice out of each unit in the syllabus.

(d) Besides, the course syllabi shall be well drafted, be defect-free and properly unitized (or modularized) to enable the distribution of questions in the question papers to cover the whole syllabus. These aspects shall have to be taken into account, in particular, by the concerned DUPCs.

(e) There shall be two types of questions to be set by the subject teacher for the question papers at both CIE and ESE, viz.,

i. Multiple Choice Questions, having each question to be answered by tick marking the correct answer from the choices (commonly four) given against it. Such a question paper shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students. Usually, no more than 15- 20% of the questions in a paper for CIE or ESE shall be of this type.
ii. Comprehensive Questions, having all questions of the regular type to be answered in detail. Such a question paper shall be useful in the testing of overall achievement and maturity of the students in a subject, through long questions relating to theoretical/practical knowledge, derivations, problem

solving and quantitative evaluation.

(f) Examinations: The College shall maintain a high standard in both CIE and ESE and ensure the declaration of final results including SGPA and CGPA of the courses attended by a student in a semester before the end of the semester as per the Academic Calendar. For meeting these requirements, the College shall take the following steps:

i. CIE shall be conducted exclusively by the subject teacher, who shall spell out the components of CIE in advance, maintain transparency in its operation, declare the evaluation results in time and return the answer scripts and assignment sheets to the students on a regular basis after the evaluation is completed. The teacher shall also solve the questions asked in the tests at the tutorial sessions for the benefit of weak students.

ii. ESE shall be preferably conducted jointly by the subject teacher and an external examiner appointed for this purpose by the College. In this case, considering the tight time schedule for the various tasks connected with ESE, the external examiner shall be associated with the teacher only in the setting of the question paper.

iii. The answer scripts of ESE shall be evaluated by the subject teacher only; but, an external review of the entire ESE shall be conducted under the aegis of the Board of Examiners of the College before declaring the results. This step shall be useful to the College to gain the confidence of the University on the fairness and transparency in the system.

iv. Suggested passing standard for each of the courses shall be 50 % of the topper marks from the CIE and ESE taken together.

v. Attendance at all examinations, both CIE and ESE of each course shall be compulsory for the students. Students having the following deficiencies shall not be permitted to attend the ESE:

A. Disciplinary action by the College pending against him/her;
B. Irregular in attendance at lecture/laboratory and other classes;
C. Failure to meet the standards of attendance prescribed;
D. CIE Performance far below the passing standard

(g) In the event of a final year student failing in a Laboratory course or scoring very low marks in the CIE of a subject or falling seriously ill during ESE, the subject teacher concerned shall have the discretion to grant the student extra time, not exceeding

12 weeks for satisfactorily completing the concerned course after awarding an I grade. If no such extra time is sought/granted, the concerned student shall have to re-register for the same in a succeeding semester and take steps to fulfill the requirements for the Degree award. The I grade shall be required to be converted into a regular grade within stipulated period indicated in the academic calendar.

(h) There shall be make- up examination for a course to take care of students with the I or X grades in ESE.

(i) Make Up Examination: This facility shall be available to students who may have missed to attend the ESE of one or more courses in a semester for valid reasons and given the I grade; also, students having the X grade shall also be eligible to take advantage of this facility. The makeup examination shall be held as per dates notified in the Academic Calendar. However, it shall be possible to hold a makeup examination at any other time in the semester with the permission of the Dean, Academic Affairs. The standard of conducting this examination shall be the same as the normal ESE.

(j) Evaluation of Project work: The project work shall be normally conducted in two stages, spread over one or two sequential semesters.

i. At the end of first stage, the student shall be required to submit for evaluation, a preliminary report of the work done before a prescribed date to the Project Coordinator, DUPC and present the same before an Internal Project Evaluation Committee. This shall be followed by taking up the second stage of work either in the same or the following semester.

ii. The Controller of Examinations shall receive a panel of names from the Chairman, DUPC for identifying the project examiners for the student, at least two weeks before the submission of the second stage of project work. This shall comprise of three unbound, typed copies of the project report (one for each examiner), prepared according to the prescribed format to be submitted to the Department at least one week before the date of oral examination.

iii. The Department shall record the date of submission of the project report and arrange to send copies of the same to the examiners a few days before the date fixed for the oral examination. The project coordinator shall notify the date of the oral examination to the examiners and also the student, with a copy marked to the Controller of Examinations. Then the project report shall be evaluated by the Project Evaluation Committee and the result submitted to the Project Coordinator, who in turn shall forward it to the Controller of Examinations.

iv. On successful completion of the oral examination, the student shall be required to submit two bound copies of the final, corrected project report, one being for the Department and the other for the project supervisor(s).

v. A student desirous of extension of time, up to a maximum of 3 months from the prescribed date for submission of the project report, shall seek permission for the same from the Project supervisor(s) and Head of the Department. The DUPC shall consider such requests, case by case, before giving the permission.

vi. If the DUPC is convinced that the progress of a student in project

work is insufficient, the concerned students shall be temporarily awarded the I grade. Further, if the project report of the student is not submitted within the extended time period, the I grade shall be automatically converted to the FF grade.

vii. Such of the students who fail in the first stage assessment of project work shall be required to re-register for the first stage in the following semester. Likewise, those who obtain the FF grade in the second stage assessment shall be required to re-register for the same in the subsequent semester(s).

(k) The evaluation of performance in EAA's shall be done by the concerned faculty members, who shall communicate the student's performance to the Examination Section, soon after the examination is conducted.

17. **Grading System**:

(a) The College shall follow the award of letter grades and the corresponding grade points to the students based on their performance at the end of every semester, as given in Table 2, In addition to the grades given in the Table 2, the instructors shall use two transitional grades I and X as described in Clause (3) in this Section.

Table 2: Letter Grades and Grade Points

Grade	Grade Points
A	10
A	9
B	8
B	7
CC	6
CD	5
DD	4
FF	0
PP (Only for Compulsory	0
AU (Audit Subject)	0
NP (Only for Non Credit Subjects)	Not Passed

(b) A student is considered to have completed a course successfully and earned the credits if he/she secures a letter grade other than I, 'X' or FF in that course.

Letter grade FF in any course implies failure in that course.

(c) The Transitional Grades I and 'X' shall be awarded by the teachers in the following cases:

i. Grade I to a student only on satisfactory attendance at classes and performance in other components of assessment, but absence from ESE in a semester for valid and convincing reasons acceptable to the Department, such as,

A. Illness or accident, which disabled him/her from appearing at the examination;

B. A calamity in the family at the time of the examination, which required the student to be away from the College;

ii. Grades X to a student on his/her overall performance in the course during the semester, highly satisfactory, i.e., high CIE rating, but a very low ESE performance resulting in an overall FF Grade in the course.

iii. All the I and X grades awarded to the students shall be converted by the teachers to appropriate letter grades and communicated to the Academic Section (through Head of the Department) within two days of the respective make-up ESEs. Any outstanding I and X grades two days after the last scheduled make-up ESEs shall be automatically converted to FF grade.

(d) A Semester Grade Point Average (SGPA) shall be computed for all the students in a Department for each semester, as follows:

$$SGPA = (C_1 * G_1 + C_2 * G_2 + C_3 * G_3 + \ldots + C_n * G_n) / (C_1 + C_2 + C_3 + \ldots + C_n)$$

where, n is the number of courses registered during the semester, C_i is the number of credits allotted to a particular course, and G_i is the grade points corresponding to the grade awarded for the course.

(e) A Cumulative Grade Point Average (CGPA) shall be computed for all the students in a Department at the end of each semester by taking into consideration their performance in the present and the past semesters as follows:

$$CGPA = (C_1 * G_1 + C_2 * G_2 + C_3 * G_3 + \ldots + C_m * G_m) / (C_1 + C_2 + C_3 + \ldots + C_m)$$

where, m is the number of courses registered upto that semester, C_i is the number of credits allotted to a particular course, and G_i is the grade points corresponding to the grade awarded for the course.

(f) Both the SGPA and CGPA shall be rounded off to the second place of decimal and recorded as such for ease of presentation. Whenever the CGPAs are to be used for the purpose of determining the merit ranking in a group of students, only the rounded off values shall be made use of.

(g) When a student gets the grade I or X for any course during a semester, the SGPA for that semester and the CGPA at the end of that semester shall be tentatively calculated ignoring the I and X graded course(s). The SGPA and CGPA for that semester shall be finally recalculated after conversion of I and X grade(s) to appropriate grade(s), taking into account the converted grade(s).

(i) Other academic requirements for the Programme include the following two certifications as indicated earlier in clause (5) of Section 10, viz., PP (Passed) and NP (Not Passed) for EAA. However, there shall be no grade points are associated with these certifications and they do not figure in the calculation of SGPA or CGPA. But, obtaining a PP shall be a mandatory requirement to qualify for, the Degree award.

(j) It shall be open to each student to take additional courses for audit from the fifth semester onwards, with the concurrence of the Faculty Advisor. Students having CGPA >= 8.0 shall be normally encouraged to take such courses. While the performance of the student in audited courses shall be included in the Grade Card, they do not contribute to SGPA or CGPA of the concerned student.

18. **Method of Awarding Letter Grades:**

(a) The subject teacher(s) shall award the letter grade(s) to students based on the marks secured by them in both CIE and ESE together in the course(s) registered. This shall be done by following a relative grading system based on the use of statistics, for which the IUPC shall make available an appropriate software package.

(b) The subject teacher(s) shall submit two copies of the result sheet for each course, giving both the marks and the grades awarded to the Head of the Department, before the due date specified in the Academic Calendar. This shall be forwarded to the Controller of Examinations soon thereafter by the Head of the

Department, after preliminary scrutiny and moderation (if necessary) at the DUPC
level.

(c) All the evaluated answer scripts of CIE in a subject shall be returned to the students from time to time during the semester. However, the answer scripts of ESE shall only be shown to the students during the specified period after the evaluation and the detailed marks sheets together with ESE answer scripts and any other relevant papers connected with ESE shall be submitted by the subject teacher(s) to the Controller of Examinations who shall hold it for a period of at least one semester. Steps shall be taken to destroy the same only after obtaining permission from the Dean of Academic Affairs at the end of the prescribed period.

(d) Appeal: A student shall have the possibility to appeal to the Director against a subject teacher for awarding lower grade in a course than that expected by him/her, on payment of prescribed fees, before the commencement of the next semester. In such a case, the DUPC shall arrange a meeting of the aggrieved student together with a Committee comprising of the subject teacher, another subject expert from the College and the Head of the Department, who shall reconsider the evaluation done, show the answer script to the student. If the student is satisfied, the matter shall be closed at this stage. On the other hand, if a revision of marks allotted is called for, the same shall be carried out and all the records, including the Grade Card, corrected soon thereafter. In the latter case, the prescribed fee paid by the student shall be returned.

(e) Withholding of Grades: The Grades of a student in a semester shall be withheld and not declared if the student fails to pay the dues to the College or has disciplinary action pending against him/her.

19. **Eligibility for the Award of Degree**:

(a) A student shall be eligible for the award of B. Tech. Degree from the College and the University provided:

i. Completed all the prescribed credit requirements for the award of Degree with grade DD or higher, in each of the courses, like Theory, Laboratory, Studio, Workshop, Seminar and Project Work;
ii. Satisfactorily completed all the non-credit requirements with PP certification, covering EAA and Industrial Training, Field work, (if any);
iii. Obtained a CGPA of >= 5.00 at the end of the semester in which he/she completes all the requirements for the award of Degree;
iv. Paid all the dues to the College including the Department, Hostels, Library and other units; and,
v. No case or disciplinary action pending against him/her.

(b) The Senate shall be the Recommending Authority for the award of B. Tech. Degree to students fulfilling the requirements specified under Clause (a) above and the Board shall be the Approving Authority.

(c) The Degree award shall then be granted by the University.

20. Eligibility for the CGPA improvement after completion of pre-requisite credits for the award of Degree:

Students who secure CGPA between 5 and 6.75 after completing the pre-requisite credits for the award of degree, and wish to improve their CGPA are permitted for CGPA improvement. Such students be permitted to withdraw their grade in a given

course with poor grade and permitted to reappear for the examinations for improving the grade and in turn CGPA.

a) Student can appear for grade improvement examination within one year from the date of passing his/her PG or UG Examination. He should not have taken (i) Leaving Certificate from the Institute and ii) Degree from University of Pune through convocation. He/she will submit a written application to dean academics seeking his/her permission to register for class improvement within one month from the date of declaration of result or one week before the date of convocation of University of Pune whichever is earlier. This application will be forwarded to dean academics through the Head of the Department from where he/she has graduated. No student will be admitted once the subject registration process of that semester ends.

b) For grade improvement student will have to take maximum 3 subjects in which he/she has secured DD or CD grades from the same semester in one stretch.

c) Student can choose maximum three theory courses from a particular semester offered for T.Y and B. Tech (either odd or even) in which he/she has secured DD or CD grade. Student will have to register for these courses in a particular semester in which those subjects are offered.

d) At the time of registration student will surrender all the original mark lists given to him by the institute He will have to give an affidavit on 100 Rs. judicial stamp paper that he/she will not do any use of surrendered mark lists till he/she gets official result of the subjects for which he/she wishes to appear for grade improvement. No change of subjects or drop of subjects will be allowed after registration.

e) Student wishing to improve his/her grade will have to pay appropriate fees as laid down by the institute time to time.

f) Student wishing to appear for grade improvement is exempted from attending regular classes as he/she has already undergone the course instructions but he/she will have to appear for all the evaluation tests conducted for the particular subjects. No re-exam or retest will be allowed for the class improvement, in case of such students misses any of the tests or examinations. Absentee for End-semester examination will automatically lead to award of FF grade in that subject.

g) The grading process as used for the regular students appearing for that subject will be applicable and no concession of any sort will be granted on account of absentee for any of the examinations.

h) Student wishing to use the facility of grade improvement will have to pass in all the three subjects at a time for which he/she has registered for. He/she will not be entitled for the summer term or re-examination in such cases.

i) Only one attempt will be permissible for any candidate wishing to use the facility of grade improvement. If the student fails to secure higher grades resulting in reduction in overall CGPA then the original result of the student before registering for grade improvement will be retained.

j) Student who improves his/her CGPA will be issued fresh mark lists by the institute. These mark lists will have star against the subjects for which he/she has appeared

for grade improvement and will state "Grade Improvement". The date on the new mark lists will be that as issued for other students appearing in those subjects. Name of the student will be communicated to Pune University and he/she will have to apply for degree certificate from University of Pune thereafter.

CURRICULUM STRUCTURE OF B. TECH (Electrical)

Effective from A. Y. 2018-2019

STRUCTURE FOR UG PROGRAM IN ELECTRICAL ENGINEERING

Semester VII [ELECTRICAL]

Sr. No.	Course Type	Course Name	Teaching Scheme			Credits
			L	T	P	
1	ILOE	Institute level Open Elective	3	0	0	3
2	LLC	Liberal Learning Course	1	0	0	1
3	DEC	Department Elective-I	3	0	0	3
4	SBC	Project Stage-I{For Normal Track} /Seminar {for Internship Track}	0	0	4	2
5	PCC1	Power System Protection	3	0	0	3
6	PCC2	Electric Drives	2	1	0	3
7	PCC3	Control System Design	2	1	0	3
8	LC1	Modeling and Simulation Lab {CSD Lab}	0	0	2	1
9	LC2	PSP Lab	0	0	2	1
10	LC3	Drives Laboratory	0	0	2	1
			14	2	10	
		Total Academic Engagement and Credits	**26**			**21**

ILOE offered by Electrical Engineering Department are:

1) Control System Engineering.
2) Electrical Installation and Practices.

Semester VIII [ELECTRICAL]

[For the students who prefer the regular track]

Sr. No.	Course Type	Course Name	Teaching Scheme			Credits
			L	T	P	
1	MLC	Intellectual Property Rights	1	0	0	0
2	LLC	Liberal Learning Course	1	0	0	1
3	PCC/HSMC	Project and Finance Management {SLC}	3	0	0	3
4	DEC	Department Elective-II	3	0	0	3
5	DEC	Department Elective-III	3	0	0	3
6	PCC1	High Voltage Engineering Lab	2	0	2	3
7	SBC	Project Stage-II			12	6
			13	0	14	19
		Total Academic Engagement and Credits	**27**			**19**

Semester VIII [ELECTRICAL]

[For the students who prefer the Internship/ full time project track]

Sr. No.	Course Type	Course Name	Teaching Scheme			Credits
			L	T	P	
1	MLC	Intellectual Property Rights	1	0	0	0
2	LLC	Liberal Learning Course	1	0	0	1
3	PCC/HSMC	Project and Finance Management	3	0	0	3
4	SBC	Major Project / Industry Internship	0	0	22	15
			5	0	22	
		Total Academic Engagement and Credits	**27**			**Max. 19**

***Refer Departmental elective list as shown below for**

Departmental Electives

ELECTIVE I					
	COURSE TITLE	L	T	P	Credits
1	Electrical Machine Design	3	0	0	3
2	Power Quality: Issues and Mitigation	3	0	0	3
3	Computer Algorithms	3	0	0	3
4	Embedded Systems	3	0	0	3
5	Any PG course / New Course suggested by DUPC	3	0	0	3

ELECTIVE II					
	COURSE TITLE	L	T	P	Credits
1	Electric and Hybrid Electric Vehicles	3	0	0	3
2	Energy Conservation & Auditing	3	0	0	3
3	Condition Monitoring of Electric Apparatus	3	0	0	3
4	Wind and Solar Power	3	0	0	3
5	Advanced Data Structures	3	0	0	3
6	Any PG Course/ New Course suggested by DUPC	3	0	0	3

ELECTIVE III					
	COURSE TITLE	L	T	P	Credits
1	Smart Grids	3	0	0	3
2	HVDC and FACTs	3	0	0	3
3	Energy Storage Systems	3	0	0	3
4	Big Data Analysis	3	0	0	3
5	Any PG Course/ New Course suggested by DUPC	3	0	0	3

MINORS COURSE

No.	Semester	Electrical Minor	Renewable Minor	Lectures	Credits
1	V	Electrical Circuit Analysis and Automatic Control Systems	Solar Energy Systems	3	3
2	VI	Machines and Drives	Wind Energy Systems	3	3
3	VII	Power Systems	Bioenergy Systems	3	3
4	VIII	Power Converters	Hydro Energy Systems	3	3

SEMESTER VII

ILOE

Control System Engineering

Teaching Scheme:
Lectures: 3 hrs/week
Tutorial : 0 hrs/week

Examination Scheme:
100 marks: Continuous evaluation-
Assignments /Quiz- 40 Marks,
End - Sem Exam – 60 Marks

Course Outcomes:
By the end of the course, students will be able to

1. Realize role of control in various industrial applications.
2. Understand various control components
3. Use tools root locus and bode plot to analyze the system.
4. Develop sequential control using contactors and relays and PLC

Unit 1 **[06 Hrs]**

Fundamentals of Control System

Introduction to control system , Block diagram of control system, Transfer Function representation of a system. Notion of feedback, open and closed -loop systems. Tracking regulator and process control systems, Linear Mathematical models, concept of poles and zeros Electric Systems, Hydraulic System, Thermal System, Pneumatic System , Electromechanical system, Transfer function and role of control in such systems

Unit 2 **[06 Hrs]**

Control System Components

Servo components: Error detectors, Potentiometer, synchros, optical rotary encoders, DC and AC Servomotors, stepper motor, gear trains, A C and DC tacho-generators, contactors, relays,

Unit 3 **[06 Hrs]**

Time Domain Analysis

Transient response of first and second order system, Time domain specification, Steady state error and static error constants. Concept of stability. Routh's stability criteria , Root Locus for system analysis

Unit 4 **[06 Hrs]**

Frequency Domain Analysis

Concept of Frequency response, gain and phase margin, Bode plot and its use for frequency domain analysis

Unit 5 **[06 Hrs]**

PID Controller

Introduction to PID control, tuning of PID gains by different methods. Use of PID controllers for various Industrial applications

Unit 6 **[08 Hrs]**

Programmable logic controller (PLC)

Basics of PLC and its application in industrial automations, process control, number systems, codes, components and systems, ladder logic design, programming, memory system and analog and discrete Input / Output system, practical control system implementation

Text Books:

- I J Nagrath and M. Gopal ,"Control system Engineering", Wiley Eastern Ltd, (3rd edition), 2000.
- Norman Nise ,"Control system Engineering", John-Willey (3rd edition,),2000.

Reference Books:

- John J. D"Azzo, C. H. Houpis,"Linear control system analysis and design (conventional and modern)", McGraw Hill International Fourth edition.
- Katsuhiko Ogata, " Modern Control Engineering", Prentice Hall of India Pvt Ltd.
- L.A. Bryan and E. A. Bryan, "Programmable Controllers – Theory and implementation," Second edition, A Industrilal text company publication, USA, 1997.

ELECTRICAL INSTALLATION PRACTICES

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
100 Marks: Contionuous evaluation
Assignments/ Quiz- 40 marks
End-sem Exam: 60 marks

Unit 1 **[05 hrs]**

Electrical lay out and distribution systems

Introduction to general electric distribution systems, residential buildings, IT sector industry (3-4 types such as sugar, plastic, mechanical, chemical), Various components and their functions, General specification and ratings, top class brands, drawing of electric ciruits, standard symbols, MCC and DCC, design issues for MCC and DCC.

Unit 2 **[08 hrs]**

Differential components in electric systems

Types of wirings, cables, Insulators, Switches, thermal relays, wires, conductors, Types of Energy meters, MCB's and MCCB's, single phase preventer and basic protection equipment, HRC fuses, capacitors for PF correction, earthing of electrical installations.

Unit 3 **[08 hrs]**

Installation of electrical devices

Various types of electric motors, selection of motors for various applications such as fans, pumps, compressors, extruders, lifts, servo drives, heating and cooling of motors, simple industrial control such as multi-speed, star/delta, forward reverse, control circuits.

Unit 4 **[08 hrs]**

Heating and lighting system design

Types of electric heating, types of industrial heaters, installation of heaters, induction heating, different terminology in illumination for different applications, standard procedure, energy conversion options such as CFL, LED lamps etc.

Unit 5 **[08 hrs]**

Typical installations

Installation of A. C.'s, UPS, inverters, D.G. sets, estimating the requirements, sizing the device, electrical system requirements, typical diagrams, AMF panel, types of UPS- on line and off line

Unit 6 **[08 hrs]**

Principle of contracting

Purchasing techniques, spot quotations, floating enquiry, typical example of quotation form, preparation of comparative statement, analysis of comparative statement, tender types(Single tender, Open tender), Earnest money, Security deposit, various steps involved in complete purchase, typical order formats, various criteria for selecting the supply, general considerations in order for procedures to be allowed for submitting the tenders and quotations.

Text Books:

- Uppal S.L., Garg S.C.,"Electrical wiring, estimation and costing", Khanna publishers, New Delhi, Sixth edition 2009.
- Surjit Singh,"Electrical Estimating and Costing", Dhanpat rai and sons Reprint 2008.
- Raina K. B., Bhattacharya S. K., "Electrical Design Estimating and Costing", New age International Publishers Reprint 2009.

DEPARTMENTAL ELECTIVE I
Electrical Machine Design

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
100 marks: Continuous evaluation
Assignments /Quiz/ Test- 40 Marks,
End - Sem Exam – 60 Marks

Course Outcomes:
By the end of the course, students will be able to

1. Select proper commercial materials, their properties and selection criterions, IS standards used in electrical machine design.
2. Design commercial transformers and induction motors as per specifications.
3. Apply computer aided optimization techniques for design of electrical machines
4. Design and analyze electrical machines using finite element based software.

Unit 1 **[06 Hrs]**

Introduction

Transformers and three phase induction motors - types, specifications, constructional features, conducting, magnetic and insulating materials, heating and cooling in electrical machines, magnetic circuit calculations.

Unit 2 **[07 Hrs]**

Transformer Design

Magnetic circuit specific electric and magnetic loadings selection, output equation, core and yoke sections, main dimensions design, core loss from design data, winding design, calculations of magnetizing current, winding resistances and leakage reactance's, losses, performance, temperature rise, cooling methods, radiators, tank wall dimensions.

Unit 3 **[06 Hrs]**

Induction Motor Design (Part I)

Output equation, specific electrical and magnetic loading, main dimensions, selection of slots, stator design, stator slots, turns per phase, selection of air gap, unbalanced magnetic pull estimation, harmonic minimization, squirrel cage and wound rotor design.

Unit 4 **[07 Hrs]**

Induction Motor Design (Part II)

Calculation of magnetic circuit, MMF calculations, stator teeth, stator core, effect of saturation, magnetizing current, no load current and its core loss component, leakage fluxes and reactance calculations, performance calculations - losses, efficiency, temperature rise, maximum torque from circle diagram.

Unit 5 **[06 Hrs]**

Computer Aided Design (CAD) of Electrical Machines

Limitations and assumptions in traditional designs, need of CAD, analysis, synthesis and hybrid methods, design optimization methods, variables, constraints and objective function, problem formulation.

Unit 6 **[08 Hrs]**

Electrical Machine Design using FEA Software packages

Introduction to complex structures of modern machines- PMSMs, BLDCs, SRM, LSPMSMs Claw pole machines etc, need of commercial FEA based software, analytical design modules, 2D and 3D machine models, analyzing steady state and transient performance of the designs.

Text Books:

- A. K. Sawhney – "A Course in Electrical Machine Design", 10th Edition, - Dhanpat Rai and sons New Delhi, 2013.
- M. G. Say –The Performance and Design of A.C. Machines, 3rd Edition, CBS Publishers and distributors, Delhi, Reprint 2002.
- S. K. Sen, "Principles of Electrical Machine Design with computer programmes", Oxford and IBH Company Pvt. Ltd. New Delhi, 2006.

Reference Books:

- A. Shanmugasundaram, G. Gangadharan, R. Palani, -Electrical Machine Design Data Book, 3rd Edition, 3rd Reprint, John Wiley Eastern Ltd., New Delhi, 1988.
- K. M. Vishnu Murthy, "Computer Aided Design of Electrical Machines", B.S. Publications, 2008.
- Electrical machines and equipment design exercise examples/ Tutorials using Ansoft's Maxwell 2D machine design package.

Power Quality Issues and Mitigation

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
100 marks: Continuous evaluation-
Assignments /Quiz-40 Marks,
End - Sem Exam – 60 Marks

Unit 1 **[08hrs]**

Electric Power Quality:

Definition; Power Quality evaluation procedures; Terms and definitions: transients, long duration voltage variations, short duration voltage variations, voltage imbalance, waveform distortion, voltage fluctuation; sources of sags and interruptions, solutions at the end user level.

Unit 2 **[06 hrs]**

Transient Overvoltages:

Sources of transient overvoltages, devises for overvoltage protection, switching transient problems with loads, computer tools for transient analysis.

Unit 3 **[08hrs]**

Fundamentals of Harmonics:

Harmonic distortion, power system quantities under nonsinusoidal conditions, harmonic indices, harmonic sources from industrial loads, effects of harmonic distortion, devices for controlling harmonic distortion, standards on harmonics.

Unit 4 **[07 hrs]**

Power Quality Monitoring:

Monitoring considerations, historical perspective of power quality measuring instruments, power quality measurement equipment, application of intelligent systems, power quality monitoring standards.

Unit 5 **[06 hrs]**

Modeling of Networks and components under nonsinusoidal conditions:

Transmission and distribution systems, resonance, shunt capacitors, transformers, electric machines, ground systems.

Unit 6 **[06 hrs]**

State Estimation applied to Power Quality Assesment:

State estimation, Least square state estimators, Kalman filters, Artificial Neural Networks.

Text Books

- Roger C. Dugan, “Electrical Power Systems Quality”, McGraw-Hill Publication, 3/e
- G.T.Heydt, “Electric Power Quality”, Stars in a Circle Publications,2/e

Reference Book

1. J. Arrillaga, N.R.Watson, "Power System Quality Assessment", John Willey & Sons, 3/e.

Course Outcomes:

Upon successful completion of this course, students will be able to:

- Learn to distinguish between the various categories of power quality problems.
- Understand the root of the power quality problems in industry and their impact on performance and economics.
- Learn to apply appropriate solution techniques for power quality mitigation based on the type of problem.
- Introduce the importance of grounding on power quality.
- Introduce power distribution protection techniques and its impact on voltage quality.

Computer Algorithms

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
100 marks: Continuous evaluation-
Assignment/Quizzes – 40 marks
End Sem Exam - 60 marks

Unit 1 **[06 Hrs]**

Introduction

Objectives of time and space analysis of algorithms; Order notations (O, Θ, Ω notations) with reference to the following algorithms: bubble sort, selection sort, insertion sort, Recurrences

Unit 2 **[06 Hrs]**

Data Structures

Arrays, Linked lists, Stacks and Queues. Binary search trees, Red-Black trees, Hash tables, Basics of graphs and their representations, Heaps and Heapsort

Unit 3 **[07 Hrs]**

Design Techniques

Divide and Conquer-Merge sort, Greedy Algorithms-knapsack problem, Backtracking-8-Queens problem.

Unit 4 **[06 Hrs]**

Selected Algorithms from various areas

Graph Theory: Elementary Algorithms, DFS, BFS, Topological Sort, Minimum spanning trees

(Kruskal and Prim's algorithms), Shortest Paths: Single Source shortest paths – Bellman-Ford algorithm, Dijkastra's algorithm, String Matching : The naïve string-matching algorithm, The Robin-Karp algorithm, The Knuth-Morris-Pratt algorithm, Geometric algorithms.

Unit 5 **[05 Hrs]**

Introduction to Advanced Algorithm Design Techniques

Amortized Analysis: Aggregate analysis, The accounting method, The potential method, Probabilistic Analysis and Randomized Algorithms, The hiring problem, Indicator random variables, and Approximation Algorithms.

Unit 6 **[06 Hrs]**

Complexity Theory

Lower-bound arguments, NP-completeness**,** Introduction to NP-Complete.

Text Books:

- Thomas Cormen, Charles Leiserson, Ronald Rivest and Cliford Stein, "Introduction to Algorithms", PHI

Reference Books:

- E. Horowitz and S. Sahni. "Fundamentals of Computer Algorithms" , Galgotia, 1991
- V. Aho, J. E. Hopcroft, and J. D. Ullman, "The Design and Analysis of Computer Algorithms",Addison Wesley, 1974

Outcomes:

1. Introduces the need of analyzing algorithms and basic techniques used in the analysis
2. Makes students aware of standard design techniques
3. Makes students aware of complexity theory
4. Students equipped with all these topics will always be keen on writing efficient code, use
   standard techniques to solve problems from different domains and go for approximate solutions when the problems are computationally hard
5. This course would give them an edge over other software professionals who know only technology.

Embedded Systems

Teaching Scheme
Lectures:3hrs/week

Examination Scheme:100
Test-I-20 Marks
Test-II-20 Marks
End-Sem Exam-60 Marks

Outcomes:

1. Understanding of ARM Cortex-M series architecture, its on-chip features and applications.
2. Hands on usage of IDE, compiler, debugger for 32-bit Microcontroller (Cortex-M series) and algorithm development.
3. To understand concepts of Operating Systems(OS) and OS based developments.
4. Study, design, analyze of embedded systems prototype development.

Unit 1 **[06 hrs]**

ARM-Cortex M series architecture

Embedded systems, classification, ARM 32-bit microcontroller Tiva, architecture—technology overview, Architectural Features of ARM Cortex M series: Tiva Block Diagram, CPU modes, register organization, ROM, RAM, timers, data and address bus, Memory and I/O interfacing concepts, memory mapped I/O. CISC Vs RISC design philosophy, Von-Neumann Vs Harvard architecture, instruction set, pipelining, exceptions and its handling, memory, I/O‘s and addressing modes.

Unit 2 **[06 hrs]**

External Interfaces with ARM-Cortex M Series Microcontroller

Compiler, debugger, writing C program, Interfacing of peripherals using Tiva: LED and sensors, ADC, Timer, PWM, Enhanced PWM, UART, SPI, I2C, wireless module interfacing, motor control.

Unit 3 **[06 hrs]**

Operating system based development

Operating systems fundamentals, operating system services, memory management, process management, device management, file management, Operating system services- program execution, I/O operation, file manipulation, communication, Operating system properties- multitasking, parallel programming, interactivity, scheduling and scheduling algorithms.
Linux: An overview of Red Hat Linux, installing Ubuntu, Linux commands, shell scrip programming, embedded Linux.

Unit 4 **[06 hrs]**

Development Tools (Open Source)

GNU tools, text editors-vi, nano, pico,etc. IDE-Eclipse, code lite, compilers-gcc, g++, debuggers, cross-compilers, gcc- arm specific tool chains and in line assembly, Writing and compiling C/C++ programs, cross-compilation for ARM development board, Basics of make file, static and dynamic libraries.

Unit 5 **[10 hrs]**

Kernel programming and RTOS

Kernel, basic functionalities of kernel, kernel module programming, Linux kernel sources, kernel configuration, booting kernel, kernel booting parameters, root file system,bootloader,U-boot,portingLinuxonARMboard,devicedriverprogramming, architecture, I/O communication, writing simple character device driver. RTOS concepts using Tiva : foreground and background systems, critical section, shared resources ,tasks, multitasking, context switching, kernels, pre-emptive and non-pre-emptive schedulers, static and dynamic priorities, priority inversion, mutual exclusion, synchronization, inter task communication mechanisms, Interrupts: latency, response and recovery, clock tick, memory requirements.

Unit 6 **[8 hrs]**

Application development

Development of web server, wireless module interfacing, camera interfacing, open CV on Beagle Bone Black. Control application, Java programming on Beagle Bone Black, porting android for mobile applications like controlling Beagle Bone Black I/O through mobile.

Text Books:

- Sloss Andrew N, Symes Dominic, Wright Chris, ‒ARM System Developer's Guide: Designing and Optimizing‖, Morgan Kaufman Publication,2004.
- Embedded Systems: Real-Time Interfacing to ARM Cortex-M Microcontrollers, 2014, Jonathan W Valvano Create space publications ISBN: 978-1463590154.
- Embedded Systems: Introduction to ARM Cortex - M Microcontrollers, 5th edition Jonathan W Valvano, Create space publications ISBN-13: 978-1477508992

Reference Books:

- Raj Kamal,―Embedded Systems – Architecture: Programming and Design‖,Tata McGraw-Hill Education, 3rd ed.,2003.

(PCC)

POWER SYSTEM PROTECTION

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
Continuous Evaluation:
Quiz/Assignments– 40 marks
End-Sem Exam - 60 Marks

Course Outcomes:

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

1. Understand the relaying principles, working of circuit breakers and L.T. switchgears.
2. Select the different components of protection system such as CT, PT, circuit breakers, relays etc.
3. Identify, formulate and solve problems in protection of transformer, generator, transmission lines, bus bar, motors etc.
4. Estimate the phasors using different algorithms and design the numerical protection system.

Unit 1 **[8 hrs]**

Fundamentals of power system protection, Instrument Transformers, Circuit Breakers

Need of protection, protection principles, protection paradigms - apparatus protection and system protection, desirable attributes of protection. Introduction to C.T., C.T. equivalent circuit, C.T. saturation and dc offset current, V.T. equivalent circuit, Ferro resonance, Circuit Breakers: arc voltage, arc interruption, resistance switching, interruption of capacitive and inductive current, circuit breaker ratings, classification of C.B.s - air break, air blast, vacuum, minimum oil and bulk oil, SF6 C.B. L.T. switchgear: - MCB, MCCB, HRC fuses, type construction and application.

Unit 2 **[06 hrs]**

Fault analysis and over current protection

Review of calculation of fault currents, C. B. selection, fuse protection, over current protection, PSM and TMS setting, phase relay coordination, earth fault protection using over current relays, introduction to directional over-current relays.

Unit 3 **[06 hrs]**

Basics of numerical relaying

Numerical relaying fundamentals, sampling theorem, anti-aliasing filters, least square method for estimation of phasors, Fourier algorithms, Fourier analysis and discrete Fourier transform, estimation of phasors from discrete Fourier transform, Applications for implantation of various numerical relays. Fundamentals of PMU and WAMS.

Unit 4 **[07 hrs]**

Transmission System Protection using distance relays

Introduction to distance relaying, zones of protection, effect of fault arc resistance, directional properties, setting and coordination of distance relays, pilot protection with distance relays, realization of distance relays using numerical relaying algorithms, Basics of load encroachment and power swing.

Unit 5 **[07 hrs]**

Protection of Transformer, Generator, Motors

Percentage differential protection, magnetic inrush current phenomenon, percentage differential relay with harmonic restraint, restricted earth fault protection, incipient faults, Buchholz relay, protection against over fluxing. Generator protection: Stator phase and ground fault protection, protection against unbalanced loading, loss of excitation, loss of prime mover and over speeding, protection of large motors.

Unit 6 **[06 hrs]**

Bus bar protection, Lightning Protection and system grounding

Bus bar protection: Different bus bar arrangements, differential protection of bus bar, high impedance differential relay. Lightening and switching over voltages, need and types of lightening arresters, insulation coordination. System grounding, need, methods of system grounding, substation ground mats.

Text Books:

- A Web Course on Digital protection of power system by Prof. Dr. S. A. Soman, IIT Bombay.
- Fundamentals of power system protection by Y. G. Paithankar, S. R. Bhide., Prentice hall, India, second edition, 2010."

Reference Books:

- Switchgear protection and power system by Sunil S. Rao, Khanna Publishers, 13th edition, 2008.
- Computer relaying for power systems by A.G.Phadke, J.S.Thorp-research studies press ltd. England John Wiley & sons Inc. New York.
- Protection of power systems by Blackburn.

ELECTRIC DRIVES

Teaching Scheme
Theory: 2 hrs/week
Tutorial: 1 hr/week

Examination Scheme
100 marks continuous evaluation
Quiz/Assignments– 40 marks
End Sem Exam - 60 marks

Unit 1 **[06 hrs]**

Basics of Electric Drives and Control

Definition, Advantages of electrical drives, Components of Electric drive system, Selection Factors, status of Electrical Drives (DC & AC), speed control and drive classifications, close loop control of drives, phase locked loop (PLL) control.

Unit 2 **[06 hrs]**

Dynamics of Electrical Drives

Motor-Load Dynamics, Speed Torque conventions and multi quadrant operation, Equivalent values of drive parameters. Load Torque Components, Nature and classification of Load Torques, Constant Torque and Constant Power operation of a Drive. Steady state stability, Load equalization.

Unit 3 **[04 hrs]**

Selection of Motor Power Rating

Thermal model of motor for heating and cooling, classes of motor duty, determination of motor ratings.

Unit 4 **[06 hrs]**

Dc Motor Drives

Dc motors and their performance starting, transient analysis, speed control, ward Leonard drives, Controlled rectifier fed drives, [full controlled3 phase rectifier control of dc separately excited motor], multiquadrant operation, Chopper controlled drives Closed loop speed control of DC motor.

Unit 5 **[06 hrs]**

Induction Motor Drives

Induction motor analysis, starting and speed control methods- voltage and frequency control, current control, closed loop control of induction motor drives, rotor resistance control, Slip power recovery – Static Kramer and Scherbius Drive, Single phase induction motor starting, braking and speed control.

Unit 6 **[04 hrs]**

Synchronous Motor and Brushless dc Motor Drives

Synchronous motor types, operation with fixed frequency, variable speed drives, PMAC and BLDC motor drives, Stepper motor drives, switch reluctance motor drives.

Text Books

G. K. Dubey, "Fundamentals of Electrical Drives",Second edition (sixth reprint), Narosa Publishing house, 2001

Reference Books:

- M. H. Rashid, "Power Electronics -Circuits, devices and Applications", 3rdEdition, PHI Pub. 2004.
- B. K. Bose, "Modern Power Electronics and AC Drives", Pearson Education, Asia, 2003.

Control System Design

Teaching Scheme:
Lectures : 2 hrs/week
Tutorial : 1 hrs/week

Examination Scheme:
100 marks: Continuous evaluation-
Assignments /Quiz- 40 Marks,
End - Sem Exam – 60 Marks

Course Outcomes:

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

1. Define the specifications of linear control systems using transfer function models, state space models, and discrete time models.
2. Perform the linear control system designs in time and frequency domains using various approaches.
3. Use graphical tools like Bode plots, Root locus plots.

Unit 1 **[08 Hrs]**

Linear Control Methods

Introduction to process control, PID control and design methods, tuning, Implementation of PID Controllers, Special Control Structures-Feed forward and ratio control, Predictive control, Cascade control

Unit 2 **[07 Hrs]**

Control System Design in time domain

Time and frequency domain design specifications and their correlation, Use of Cascade compensation to improve systems performance, Lead, Lag and Lag-lead compensators and their role in improvement of system behavior, Design of Lead, Lag and Lag-lead in time domain using root locus.

Unit 3 **[07 Hrs]**

Control System Design in frequency domain

Lead compensator, Lag compensator, their design in frequency domain using Bode plots, Lag-Lead compensator design in frequency domain.

Unit 4 **[07 Hrs]**

State Space Analysis of Continuous System

Review of state variable representation of continuous system, conversion of state variable models to transfer function and vice-versa, solution of state equations and state transition matrix, controllability and observability, design of state feedback controller and observer.

Unit 5 **[06 Hrs]**

Discrete System

Discrete system and discrete time signals, state variable model and transfer function model of discrete system, conversion of state variable model to transfer function model and vice-versa, modeling of sample hold circuit,

Unit 6 **[06 Hrs]**

Analysis of Discrete Systems:

Solution of state difference equations, steady state accuracy, Stability of discrete systems in the z-plane and Jury stability criterion, bilinear transformation.

Text/Reference Books:

1. M. Gopal, "Digital Control and State variable Methods", Tata Mc Graw Hill
2. Ajit K.Madal, "Introduction to Control Engineering: Modeling, Analysis and Design" New Age International.
3. S.Mukhopadhyay, S.Sen, A.K.Dev," Industrial Instrumentation, Control and Automation", Jaico Publication House
4. B.C. Kuo, "Digital Control Systems" Sounders College Publishing
5. I.J.Nagrath, M.Gopal,"Control System Engineering", New Age International.

Modeling and Simulation Lab {CSD Lab}

Teaching Scheme:
Lab : 2 hrs/week

Examination Scheme:
100 marks: Continuous evaluation-

Course Objectives:

1. This course provides a control system design experience. Students will learn how to apply control system theory and engineering laboratory fundamentals to model and characterize dynamic systems and synthesize single-input/single-output control systems using classical control methods.
2. During the course, students will design and implement control systems for several mechanical systems.

Following experiments and MATLAB based assignments are to be carried out by the students:-

1. PID control design and verification for temperature control system.
2. Controller Design (Root Locus and Bode plots) using SISO tool in MATLAB.
3. Position Control of DC Motor.
4. Pole Placement by State Feedback in MATLAB.
5. Discretization and study of a practical system with understanding of effect of sampling time on stability.
6. Magnetic levitation system design.

POWER SYSTEM PROTECTION LAB

Teaching Scheme:
Practical: 2 hr/week

Examination Scheme:
Term Work : 50 Marks
Oral/Practical : 50 Marks

Course Outcomes:
At the end of this course students will be able to:

1. Carry out tests on various equipments e. g. fuse, MCB, earth tester, Megger, relays etc. and analyze the test results.

2. Simulate and analyze the symmetrical and unsymmetrical faults, Implement phasor estimation and relay coordination algorithms.

3. Perform simulation and modeling of protection system using MATLAB/PSCAD/ATP.

The laboratory consists of minimum eight experiments from following list and any other experiment based on the prescribed syllabus.

- To study various fuses and plot inverse time characteristic of fuse.
- To demonstrate the operation of various MCBs, ELCBs, MCCBs and plot inverse time characteristics of MCBs. Study of MCB protection co-ordination
- To use earth tester and compute resistance of earthing system.
- To use Megger and measure insulation resistance of wiring installation, cable, MCBs, insulators etc.
- To demonstrate the operation of Air circuit breaker.
- To test over current relay and plot its characteristics.
- To test under/over frequency relay.
- To demonstrate and plot differential relay characteristics.
- To demonstrate and plot distance relay characteristics.
- To compute fault current level /MVA for a symmetrical three phase fault and verify it by Simulation.
- To compute fault current level /MVA for unsymmetrical faults and verify it by Simulation.
- To estimate phasor from given signal using two sample/ three sample method.
- To estimate phasor from given signal using full cycle and half cycle Fourier algorithm.
- To compute the relay settings and coordinate backup over-current relays
- Visit to HV/EHV substation
- Visit to power generating station
- Visit to Switchgear Training center
- Visit to CT –PT/ circuit breaker/ relay manufacturing company.

DRIVES LABORATORY

Teaching Scheme:
Practical: 2 hr/week

Examination Scheme:
Term Work : 50 Marks
Oral/Practical : 50 Marks

The list of practical to be performed as the part of the course

1. Modeling of separately excited DC Motor (system identification / parametric measurement).
2. Armature control of S.E.DC Motor - Constant Torque, Constant HP.
3. Four quadrant DC Drive - Motoring and Braking
4. T-N characteristics using voltage control
5. T-N characteristics using V/F control
6. T-N characteristics of different loads
7. Simulation of closed loop DC drive
8. Simulation of closed loop V/F drive

9. Study ofcommercial AC and DC drives.

Outcomes:

At the end of this course students will demonstrate the ability to:

- To understand the basics of electric drives and fundamentals of drive dynamics
- To learn and analyze DC drive
- To learn and analyze different steady state speed control methods for Induction motors, and understand the closed loop block diagrams for different methods.
- To get introduced to modern synchronous motors and drives**.**

ELECTRICAL MINOR

Power Systems

Teaching Scheme
Lectures :3 hrs/week
Tutorial : ----

Examination Scheme
100 marks: Continuous evaluation-
Assignments /Quiz- 40 Marks,
End - Sem Exam – 60 Marks

Unit 1 **[06 hrs]**

General Overview of Power Systems:

Structure of Power Systems, Power System Scenario in India and world, Concept of complex power, per unit system, Skin effect, Proximity effect, Ferranti Effect, Transposition of Lines, Phenomenon of Corona, Mechanical sag

Unit 2 **[07 hrs]**

Power System Components and modelling:

Model of Synchronous Generator, Steady State Characteristics, Modeling of Power Transformer, Transmission line models: short, medium and long lines, Surge impedance Loading, ABCD Constants, Power Transmission Capability, Power System Load Modeling.

Unit 3 **[07 hrs]**

Power System Analysis:

Load Flow Analysis: Basic Load Flow Equations, Gauss-Seidel Method of Solution, Newton-Raphson Method, Comparison of Load Flow Methods.

Fault Analysis: Transients on a transmission lines, Short Circuit of a Synchronous Machine, Selection of a Circuit Breaker, Introduction to Symmetrical Components, Brief Analysis of LG, LLG and LL Faults

Unit 4 **[06 hrs]**

Power System Stability:

Concept of Stability, Definition, Steady State and Transient Stability, Swing Equation, Equal Area Criterion, Factors affecting Stability.

Unit 5 **[07 hrs]**

Power System Operation & Control:

Operating States of Power System, Generator Capability Curve, Power System Constraints-Dielectric, Thermal & Stability, Objectives and Implementation of Load Frequency Control and Automatic Generation Control, Economic Operation of Power System, Unit Commitment, Optimum Generation Scheduling Problem, Electricity Pricing, Demand Side Management.

Unit 6 **[07 hrs]**

Power System Protection:

Fundamentals and Objectives of Protection, Current Transformer and Potential Transformer, Circuit Breaker-Operating Principle and Types, Brief Principle of Overcurrent, Earth Fault, Distance and Differential Protection, Introduction to Microprocessor based and Numerical Relaying.

Text Books

- I.J. Nagrath & D.P. Kothari, 'Modern Power System Analysis', Tata McGraw Hill, 3rd Edition
- Grainger John J. and William D. Stevenson, McGraw Hill, 2nd Edition.

Reference Book

1. Hadi Sadat, 'Power System Analysis', McGraw Hill, 1999
2. Prabha Kundur, 'Power System Stability and Control', McGraw Hill, 1994

Outcomes:

At the end of this course students will demonstrate the ability to:

- Understand structure of power system and to model power system components.
- Analyze various faults on power systems for fault current computations.
- Understand the concept of steady state and transient stability with its evaluation.
- Get the knowledge of power system operation and control strategies.
- Grasp the working of circuit breakers and different protection schemes

RENEWABLE MINOR

Bioenergy Systems

Teaching Scheme:
Lectures: 3 hrs/week
Field Visit: As necessary

Examination Scheme:
MCQ-1: 20 Marks
Review Project: 20 Marks
End-Semester Exam: 60 Marks

Unit 1 **[06 Hrs)]**

Basics of Bioenergy and Resources:

Introduction to bioenergy, biomass availability in India, dealing with agricultural residue, agro industry residue, environment pollution and biomass, biomass cultivation, biomass and carbon cycle, algae as source of biomass.

Unit 2 **[08 hrs]**

Introduction to Biomass to Energy Technologies:

Biomass burning, gasification of biomass, biomass reforming, anaerobic digestion, types of digesters, biogas purification, biogas bottling, biogas to electricity, aerobic composting, organic fertilizers, biomass to liquid fuel, biodiesel, vegetable oil, biomass refinery, segregated organic waste management.

Unit 3 **[08 hrs]**

Basics of Key Equipment for Bioenergy:

Size reduction equipment shredder, grinder, pulverizer, hammer mill, mud pump, Solid handling pump, macerator, agitator, hydraulic stirrer, solid-liquid separator, decanter centrifuge, screw press, biogas scrubbing systems, gas compressors, blowers, storage tanks and cylinders, fertilizer processing equipment, piping for biogas and biodiesel, dehumidifier.

Unit 4 **[08 hrs]**

Bioenergy for Vehicles and Power Plants:

Biodiesel engines, compressed bio-methane engines, dual fuel engines, multiple fuel engines, vehicular application of bioenergy, biomass gasifier based power plants, biogas power plants with engines and turbines, non-edible waste oil based power generation, biodiesel based electricity generation.

Unit 5: **[06 hrs]**

Economics of Bioenergy Systems:

Life cycle costing, holistic payback, calculations, return on investment; calculations for selection, costing and payback for various bioenergy solutions for applications such as process heating, cooking, vehicle operation, power generation; Environmental impact assessment.

Unit 6: **[04 hrs]**

Field Visit:

One or more of the following visits may be undertaken.

- Biogas plant for segregated municipal waste
- Spent wash based biogas plant with purification and bottling facility
- Biogas fertilizer power plant
- Biodiesel manufacturing plant
- Biomass gasifier based village power plant

Reference Books:

- Biogas Technology, by B. T. Nijaguna, New Age International, 2006
- Monitoring the Anaerobic Digestion Process, by Harry Michael Falk, thesis for Doctor of Philosophy in Biochemical Engineering, School of Engineering and Science, Jacobs University, Germany, December 2011
- The Biodiesel Handbook, Editors Gerhard Knothe et al, Acos Press, Champaign, Illinois, USA
- Handbook of Biomass Downdraft Gasifier Engine Systems, National Renewable Energy Laboratory, Golden Colorado, USA
- Various research papers on biogas, biomass gasification and biodiesel
- Articles from suppliers of various biomass based energy systems, including engines
- ASTM, DIN and BIS standards

Course Outcomes:

Students will be able to:

- Understand the basics of biomass to energy, availability of biomass resource, biofuels, organic fertilizers, various types of bioenergy systems, introduction design, development, construction, installation and commissioning of bioenergy systems, measurements and characterization, quality assurance, standards, certification and economics.
- Field visits will be designed for firsthand experience and demonstration of the system elements.
- Know and recall core knowledge of the syllabus. (To measure this outcome, questions may be of multiple choice type or of the type define, identify, state, match, list, name etc.)
- Understand basic concepts. (To measure this outcome, questions may be of the type explain, describe, illustrate, evaluate, give examples, compute etc.)

SEMESTER VIII

Intellectual Property Rights

Teaching Scheme | **Examination Scheme**

Lectures:1 hrs/week | End-Sem Exam- 50

Course Objectives:

- To understand the need of awareness and knowledge about IPR.
- To understand how IPR contributes to the economic development of the society and in turn the nation.
- To understand that IP is a law, economics, technology and business.
- Understand how IPR protection provides an incentive to inventors for further research work and investment in R & D.

Unit 1 **[02hrs]**

Introduction

Nature of Intellectual Property, Patents, Designs, Trademarks and Copyrights, Process of patenting and Development-technological research, Innovation, patenting, development.

Unit 2 **[02hrs]**

International Scenario

International cooperation on Intellectual Property, Procedure for grants of patents, patenting under PCT.

Unit 3 **[03hrs]**

Patent Rights

Scope of Patent Rights, Licensing and transfer of technology, Patent information and databases, Geographical Indications.

Unit 4 **[03hrs]**

New developments in IPR

Administration of Patent system, New developments in IPR, IPR Biological systems, Computers, Software etc., Traditional knowledge, Case studies, IPR and IIT's objectives towards learning IPR.

Unit 5 **[03hrs]**

Trademark and patenting

Registered and unregistered trademarks, designs, concepts, idea patenting.

Outcomes:

i. Understood the importance of IPR.
ii. Understood how IPR are regarded as a source of national wealth and mark of an economic leadership in the context of global market scenario.

Text Books

Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd.,2nd ed. 2007.

Reference Books

Robert P. Merges, Peter S. Meneil, Mark A. Lemley, "Intellectual Property in New Technological Age", Aspen Publishers, 4th ed., 2007

Project and Finance Management

Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/week (Mooc Course) each,	T1, T2 – 20 marks End-Sem Exam – 60

Course Outcomes:

After studying this course student will be able to,

A. Demonstrate project management skills

B. Analyze risk and manage it.

C. Illustrate project financial evaluation

Course Contents:

Project organization and contracts, Construction finance, Public-private partnerships in financing of infrastructure, Private finance initiative, Project finance, How to get involved in private finance, Risk analysis, Risk management, Project financial evaluation, Capital program management, Project control, Project management engineering, procurement and construction, Identifying and covering risks—current trends, Project uncertainty management. Term project presentation

References:

- Online Mooc course material available in the selected area.

DEPARTMENTAL ELECTIVE II

Electric and Hybrid Electric Vehicles

Teaching Scheme
Lectures: 3 hrs/week
Tutorial : ----

Examination Scheme
100 marks: Continuous evaluation-
Assignments /Quiz-40 Marks,
End - Sem Exam – 60 Marks

Unit 1 **[07 hrs]**

Introduction to EVs & HEVs:

A brief history of EV &PHV, Basics of EV & HEV, Architectures of EV & HEV, HEV fundamentals.

Unit 2 **[07 hrs]**

Plug-in HEVs :

Introduction to PHEVs, PHEV architectures, Power management of PHEVs, Fuel economy of PHEVs, PHEV design & component sizing, Vehicle-to-grid technology.

Unit 3 **[04 hrs]**

Power Electronics in EVs & HEVs :

Introduction, Principles of power electronics, Rectifiers, Converters, Inverters, Battery chargers used in EVs & HEVs, Emerging power electronic devices

Unit 4 **[06 hrs]**

Electric Machines & Drives in EVs & HEVs :

Introduction, Induction motor drives, Permanent magnet motor drives, Brushed & Brushless DC motor, Switched reluctance motors

Unit 5 **[06 hrs]**

Components & design considerations of EVs & HEVs :

Batteries, Ultracapacitors, Fuel Cells, Controls, Aerodynamic considerations Consideration of rolling resistance, Transmission efficiency, Consideration of vehicle mass, Electric vehicle chassis & body design, General issues in design

Unit 6 **[06 hrs]**

Modelling, Simulation & case studies of EVs & HEVs :

Introduction, Fundamantals of vehicle system modeling, HEV modeling using ADVISOR & PSAT, Case studies - Rechargeable battery vehicles, Hybrid vehicles

Text Books:

- Chris Mi, M. AbulMasrur, David WenzhongGao, "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives", 2011, Wiley publication.

Reference Books:

- Allen Fuhs, "Hybrid Vehicles and the future of personal transportation", 2009, CRC Press.
- James Larminie, John Lowry, "Electric Vehicle Technology Explained", 2003, Wiley publication.

Course Outcomes:

At the end of this course students will understand:

- Concept of Electric Vehicles, Hybrid Electric Vehicles & Plug in Hybrid Electric Vehicles
- Power electronics & electric machine requirements of EVs & HEVs
- Design issues of EVs & HEVs
- How to model EVs & HEVs

Energy Auditing and Conservation

Teaching Scheme:
Lectures : 3 hrs/week
Tutorial : ----

Examination Scheme:
100 marks: Continuous evaluation-
Assignments /Quiz- 40 Marks,
End - Sem Exam – 60 Marks

Course Outcomes:
At the end of this course students will demonstrate the ability to:

1. Ability to apply this knowledge of science, mathematics, and engineering principles for solving problems.
2. Ability to identify, formulate and solve electrical engineering problems in the broad areas like electrical and mechanical installations, electrical machines, power systems.
3. Ability to exhibit management principles and function as a member of a multidisciplinary team.
4. Sensitivity towards professional and ethical responsibility.
5. Ability to communicate effectively in writing as well as through public speaking.

6. Ability to appreciate and engage in lifelong learning.
7. Knowledge of contemporary issues.
8. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Unit 1: Energy Scenario [05 Hrs]

Energy sources-Primary and Secondary, Commercial and Non-commercial, Energy scenario in India and Global scenario, Energy Security, Energy and GDP, Energy Intensity, Energy conservation and its importance, Energy Conservation Act 2001 and related policies, Role of Non- conventional and renewable energy.

Unit 2: Energy Management and Integrated Resource Planning [06 Hrs]

Definition and Objectives of Energy management, Energy management strategy, Key elements, Responsibilities and duties of Energy Manager, Energy efficiency Programs, Energy Monitoring System, Importance of SCADA, Analysis techniques, Cumulative sum of differences (CUSUM)

Unit 3: Energy Audit [06 Hrs]

Definition, need of energy Audit, Types of Energy Audit, Maximizing system efficiency, Optimizing the input energy requirements, fuel and energy substitution, Energy Audit instruments and metering, thermography, SMART metering

Unit 4: Financial Analysis and Management [07 Hrs]

Investment need, Financial analysis techniques, Calculation of Simple Pay-back period, return on investment, cash flows, risk and sensitivity analysis, Time value of money, Net Present value, Breakeven analysis, Cost optimization, Cost and Price of Energy services, Cost of Energy generated through Distributed Generation

Unit 5: Energy Efficiency in Electrical Utilities [07 Hrs]

Electrical billing, power factor management, distribution and transformer losses, losses due to unbalance and due to harmonics, Demand Side Management, Demand-Response, Role of tariff in DSM and in Energy management, TOU tariff, Power factor tariff, Integrated Resource Planning and Energy Management

Energy conservation in Lighting systems, HVAC, Electric Motors, Pump and Pumping systems

Unit 6: Energy Efficiency in Thermal Systems [06 Hrs]

Fuels and combustion, properties of Fuel Oil, coal and gas, storage and handling of fuels, principles of combustion, combustion of oil, coal, gas.

Energy efficiency in Boilers, Steam systems, Furnaces, Insulation and Refractors.

Text Books:

- Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-1, General Aspects (available online)
- Guide books for National Certification Examination for Energy Manager / Energy

Auditors Book-2, Thermal Utilities (available online)

- Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-3, Electrical Utilities (available online)
- Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-4,(available online)

Reference Books:

- S. C. Tripathy, "Utilization of Electrical Energy", Tata Mc Graw Hill
- Success stories of Energy Conservation by BEE, New Delhi (www.bee-india.org)

Condition Monitoring of Electrical Apparatus

Teaching Scheme:
Lectures: 3 hrs/week
Tutorial : -------

Examination Scheme:
100 marks: Continuous evaluation-
Assignments /Quiz/ Test- 40 Marks,
End - Sem Exam – 60 Marks

Course Outcomes:
By the end of the course, students will be able to

4. Understand the necessity of condition monitoring and reliability.
5. Have knowledge about the conventional and modern methodologies/techniques.
6. Develop basic functional models for condition monitoring system to different kind of power apparatus.
7. Determine life expectancy of the equipment

Unit 1: Basic Considerations and Maintenance [07 Hrs]
Basic definitions, terminologies, symbolic representation, Necessity from technical social, financial aspect, types of faults in electrical equipments {Electrical equipments such as transformer, CT/PT and rotating electrical machines, CBs, etc.}, maintenance strategies, breakdown maintenance, planned, preventative and condition based maintenance

Unit 2: Testing of Electrical Equipments [06 Hrs]
Cables, Transformers, Induction motor, Capacitor banks, conventional methods, Measurement of insulation resistance, Diagnostic Testing: Routine tests, type tests, special tests, offline tests, Causes of failure and remedies.

Unit 3: Analysis tools [06 Hrs]
Recent methods (offline), Dissolved Gas Analysis (DGA), Dissipation Factor (tan δ), Sweep

Frequency Response Analysis (SFRA), Partial Discharge (PD), Time Domain Dielectric Response (TDDR), Frequency Domain Spectroscopy (FDS), Chemical analysis. Image processing techniques.

Unit 4: Online condition monitoring and instrumentation [06 Hrs]

Recent methods (online), vibration, chemical and temperature monitoring, sensor and data acquisition system, Modern algorithms, GA, and signal processing techniques. Application to various equipments such as transformer, induction motor, synchronous generator and motor, DC motor, CT and PT, case studies.

Unit 5: Current, Flux and Power Analysis [06 Hrs]

Discrete time Fourier series and its convergence, discrete time Fourier Transform, its properties, frequency response. Introduction to DFT in time domain and frequency domain, Derivation of DFT from DTFT, Inverse DFT, Convolution using DFT, Computational Complexity of the DFT, Decimation-in-time FFT Algorithm, Decimation In Frequency FFT Algorithm, Wavelet transform, Lab view platform

Unit 6: Reliability and failure rate Assessment [08 Hrs]

Comparison of DIT AND DIF algorithms. Introduction to FIR and IIR Filter Design. Calculation of Power Equipment Reliability for Condition-based Maintenance Decision-making, Optimum Reliability- Centered Maintenance, Cost Related Reliability Measures for Power System Equipment, Reliability based replacement refurbishment/planning.

Text Books:

- P. Vas, “Parameter estimation, condition monitoring and diagnosis of electrical machines”, Clarendon Press Oxford, 1993.
- P. Tavner, Li Ran, J. Penman and H. Sedding, “Condition monitoring of rotating electrical machines”, IET press, 2008.

Reference Books:

- Xose M Lo´pez, Ferna´ndez, H Bu¨lent Ertan, J Turowski, “Transformers analysis, design, and measurement”, CRC Press, 2012
- S.V. Kulkarni and S. A. Khaparde, “Transformer Engineering: Design, Technology and Diagnostics”, Second edition, CRC Press, 2013
- R. Billinton and R. N. Allan*, “* Reliability Evaluation of Power Systems, 2nd ed. New York”, NY, USA: Plenum, 1996.
- Videos on Transformer condition evaluation with ABBs Mature Transformer Management Program
- Induction motor condition monitoring with ABBs, Siemens, General Electricals (source You Tube)

Wind and Solar Power

Teaching Scheme
Lectures: 3hrs/week

Examination Scheme
100 marks: Continuous evaluation-
Assignments /Quiz-40 Marks,
End - Sem Exam – 60 Marks

Course Outcomes:

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

1. Appreciate the importance of renewable energy sources.
2. Demonstrate the knowledge of the generation aspects of wind power and issues for grid integration.
3. Demonstrate the knowledge of solar power generation and the associated issues.
4. Identify, formulate and solve the problems of based on wind and solar power.

Unit 1 **[08 hrs]**

Physics of Wind Power

History of wind power, Indian and Global statistics, Wind physics, Betz limit, Tip speed ratio, stall and pitch control, Wind speed statistics-probability distributions, Wind speed and power - cumulative distribution functions, site selection and layout of wind farm.

Unit 2 **[06 hrs]**

Wind generator topologies

Fixed and Variable speed wind turbines, Power electronics converters, Wind generator topologies, Voltage and Reactive power control, Power quality standards for wind turbines, review of modern wind turbine technologies.

Unit 3 **[06 hrs]**

Network Integration Issues

Overview of grid code technical requirements for wind farms - real and reactive power regulation, voltage and frequency operating limits, wind farm behavior during grid disturbances, power system interconnection experience in the world, Economic aspects, Hybrid and isolated operations of wind farms.

Unit 4 **[06 hrs]**

The Solar Resource

Introduction, solar radiation spectra, solar geometry, Earth Sun angles, observer Sun angles, solar day length, Estimation of solar energy availability.

Unit 5 **[06 hrs]**

Solar photovoltaic

Technologies-Amorphous, monocrystalline, polycrystalline; V-I characteristics of a PV cell, PV module, array, Maximum Power Point Tracking (MPPT) algorithms.

Unit 6 **[08 hrs]**

Solar thermal power generation

Technologies, Parabolic trough, central receivers, parabolic dish, Fresnel, solar pond, elementary analysis, prospects for India.

Text Books:

- Gilbert M. Masters, "Renewable and Efficient Electric Power Systems", John Willy and sons, 2004, ISBN0-471-28060-7.
- S.P. Sukhatme, "Solar Energy", Tata McGrew Hill, second edition, 1996, ISBN 0-07-462453-9.

Reference Books:

- Thomas Ackermann, Editor, "Wind Power in Power Systems", John Willy and sons ltd., 2005,ISBN 0- 470-85508-8.
- Siegfried Heier, "Grid integration of wind energy conversion systems" John Willy and sons ltd.2006.
- Mullic and G.N.Tiwari, "Renewable Energy Applications", Pearson Publications.
- John A. Duffie, William A. Beckman, "Solar Engineering of Thermal Processes", Wiley Inter science Publication, 1991.

Advanced Data Structures

Teaching Scheme:	**Examination Scheme:**
Lectures : 3 Hrs/week	Assignment/Quizzes – 40 marks End Sem Exam - 60 marks

Course Outcomes:

Students will be able to:

1. Apply software development life cycle in software industry.
2. Identify the importance of software requirements problem to understand the requirement management process.
3. Design and analyze effective use of UML using different design strategies.
4. Devise the procedure to assure the quality and maintainability of the product before and after deployment.
5. Summarize different testing strategies.

Unit 1 **[06 Hrs]**

Review of Basic Concepts:

Abstract data types, Data structures, Algorithms, Big Oh, Small Oh, Omega and Theta notations, Solving recurrence equations, Master theorems, Generating function techniques, Constructive induction

Unit 2 **[10 Hrs]**

Advanced Search Structures for Dictionary ADT

Splay trees, Amortized analysis, 2-3 trees, 2-3-4 trees, Red-black trees, Randomized structures, Skip lists, Treaps, Universal hash functions, Trie ; **Hashing:** Simple tabulation hashing; chaining, dynamic perfect hashing, linear probing, cuckoo hashing

Unit 3 **[06 Hrs]**

Union Find Related Structures

Union-Find: Merging Classes of a Partition, Union-Find with Copies and Dynamic Segment Tree, List Splitting, Problems on Root-Directed Trees, Maintaining a Linear Order

Unit 4 **[06 Hrs]**

Data Structures for Partition ADT

Weighted union and path compression, Applications to finite state automata minimization, Code optimization

Unit 5 **[04 Hrs]**

Data Structure Transformations

Making Structures Dynamic, Making Structures Persistent

Unit 6 **[08 Hrs]**

Computational Geometry

Geometric data structures, Plane sweep paradigm Convex Hull Different Paradigms and Quickhull , Dual Transformation and Applications , Lower Bounds on Algebraic tree model , Point Location and Triangulation

Text Books:

- Introduction to Algorithms; 3rd Edition; by by Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein; Published by PHI Learning Pvt. Ltd. ; ISBN-13: 978-0262033848 ISBN-10: 0262033844
- Algorithms; 4th Edition; by Robert Sedgewick and Kevin Wayne; Pearson Education, ISBN-13: 978-0321573513
- Advanced Data Structures, Peter Brass, Cambridge University Press, ISBN-13: 978-0521880374

Reference Books:

- Algorithms; by S. Dasgupta, C.H. Papadimitriou, and U. V. Vazirani Published by Mcgraw-Hill, 2006; ISBN-13: 978-0073523408 ISBN-10: 0073523402
- Algorithm Design; by J. Kleinberg and E. Tardos; Published by Addison-Wesley, 2006; ISBN-13: 978-0321295354 ISBN-10: 0321295358
- Pankaj Jalote, “An Integrated Approach to Software Engineering”, Narosa publication house.
- Fred Brooks, “Mythical Manmonths”, www.cs.drexel.edu/~yfcai/CS451/.

DEPARTMENTAL ELECTIVE III

Smart Grids

Teaching Scheme
Lectures: 3 hrs/week
Tutorial : ----

Examination Scheme
100 marks: Continuous evaluation-
Assignments /Quiz-40 Marks,
End - Sem Exam – 60 Marks

Unit 1 **[05 hrs]**

Introduction to Smart Grid:

Concept, definitions, difference between conventional and smart grid, challenges in smart grid implementation, Overview of the technologies required for the Smart Grid.

Unit 2 **[07 hrs]**

Information and Communication technology:

Communication requirements in smart grid, overview of smart grid standards, Wired and wireless communication, Zigbee, Wireless mesh, Cellular Network Communication, Power line Communication, Digital Subscriber Lines, Wi-Max, Wide Area Network, Neighborhood Area Network, and Home Area Network, information technology, cyber security, standards, data handling, interoperability.

Unit 3 **[06 hrs]**

Smart Transmission System:

Phasor Measurement unit, Phasor data concentrators, Wide area measurement control and protection, Wide area measurement systems and its applications, Flexible Alternating Current Transmission Systems. High-voltage Direct-current Transmission.

Unit 4 **[06 hrs]**

Smart Substation:

International Electrotechnical Communication 61850 standards and benefits,IEC Generic Object Oriented Substation Event - GOOSE, IEC 61850 Substation model,Intelligent Electronic Devices integration, Substation LAN, WAN, SCADA, Substation automation.

Unit 5 **[06 hrs]**

Smart Distribution Systems and Energy Storage:

Introduction to Smart Meters, Real time pricing, Smart appliances, Automatic meter reading(AMR), Demand response,Battery storage, Plug in Hybrid electric vehicles, compressed air, pumped hydro, ultra capacitors, fly wheels, fuel cells.

Unit 6 **[06 hrs]**

Renewable energy integration:

Carbon Footprint, Renewable Resources: Wind and Solar, Microgrid Architecture, Modeling

PV and wind systems, Tackling Intermittency,Issues of interconnection, protection & control of microgrid, Islanding.

Text Books:

- JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", Wiley, March 2012.
- Jean Claude Sabonnadière, NouredineHadjsaïd, "Smart Grids", Wiley Blackwell, 2012.

Reference Books:

- Smart Grid: Fundamentals of Design and Analysis (IEEE Press Series on Power Engineering) by James Momoh, Mar 20, 2012.
- Ali Keyhani, Mohammad N. Marwali, Min Dai "Integration of Green and Renewable Energy in Electric Power Systems", Wiley, November 2009.
- Stuart Borlase, "Smart Grids (Power Engineering)", CRC Press, October 2012.
- Recent literature on Smart Grid.

Outcomes:

At the end of this course students will understand:

- The various aspects of the smart grid, including technologies, components, architectures and applications.
- The issues and challenges involved.
- Current initiatives in the development of smart grid at national and international level.
- The role of communication and information technology in smart grid.

HVDC AND FACTS

Teaching Scheme
Lectures: 3 hrs/week
Tutorial : ----

Examination Scheme
100 marks: Continuous evaluation-Assignments /Quiz-40 Marks,
End - Sem Exam – 60 Marks

Unit 1 **[06 hrs]**

Introduction to HVDC:

Introduction of DC Power transmission technology – Comparison of AC and DC transmission, Application and Description of DC transmission system, Planning for HVDC transmission, Modern trends in DC transmission, Types of HVDC Systems.

Unit 2 **[07 hrs]**

Analysis of HVDC Converters:

Pulse Number-Choice of converter configuration, simplified analysis of Gratez circuit, 12-pulse converter based HVDC systems and their characteristics, Control of Converters.

Unit 3 **[10hrs]**

Harmonics and Filters:

Introduction – Generation of Harmonics, Design of AC filters and DC filters, HVDC light and HVDC PLUS (Power Universal Link), Series and Parallel operation of converters.

Unit 4 **[07 hrs]**

Introduction to FACTS:

The concept of flexible AC transmission – reactive power control in electrical power transmission lines, uncompensated transmission line, Introduction to FACTS devices and its importance in transmission Network, Introduction to basic types of FACTS controllers , Comparison of HVDC and FACTS.

Unit 5 **[10 hrs]**

Shunt and Series Compensation:

Principles of series and shunt compensation, description of static var compensators (SVC), thyristor controlled series compensators (TCSC), static phase shifters (SPS), static synchronous series compensator (SSSC), STATCOM.

Unit 6 **[08hrs]**

Hybrid FACTS Controllers:

Unified Power Flow Controller (UPFC) – Principle of operation, modes of operation, applications, IPFC, Modelling and analysis of FACTS Controllers.

Text Books:

- K.R. Padiyar, "HVDC Power Transmission System", Wiley Eastern Limited, New Delhi, First Edition 1990.
- T.J.E. Miller, "Reactive Power Control in Electrical System", John Wiley and Sons, New York, 1982.
- N.G. Hingorani, "Understanding FACTS: Concepts and Technology of FACTS Systems", IEEE Press, 2000.
- K.R. Padiyar" FACTS Controllers in Power Transmission and Distribution", New Age International (P) Ltd. 2007.
- A.T. John, "Flexible AC Transmission System", Institution of Electrical and Electronic Engineers (IEEE) 1999.

References

- Colin Adamson and N.G.Hingorani ," High Voltage Direct Current Power Transmission", Garraay Limited, London 1960.
- J.Arrillaga, " High Voltage Direct Current Transmission", Peter Pregnnus, London 1983.
- Edward Wilson Kimbark," Direct Current Transmission", Vol.1 iley Interscience, New York, London Sydney 1971.
- Narin G. Hingorani, "Power Electronics in Electric Utilities: Role of Power Electronics in Future power systems", Proc. of IEEE, Vol.76, no.4, April 1988.
- Einar V. Larsen, Juan J. Sanchez-Gasca, Joe H. Chow, "Concepts for design of FACTS Controllers to damp power swings", IEEE Trans On Power Systems, Vol.10, No.2, May 1995.
- Gyugyi L., "Unified power flow control concept for flexible AC transmission", IEEE Proc-C Vol.139, No.4, July 1992.

Outcomes:

On completion of the course the students will be able to:

- Analyze the different control strategies for power flow using HVDC and FACTS devices.
- Will be able to understand the working of different FACTS controllers.
- They will be able to be in touch with the latest advances in Power Electronics.

Energy Storage Systems

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
T1, T2 – 20 marks each,
End-Sem Exam – 60

Course Outcomes:
At the end of the course the students will be able to,
A. Understand the emerging needs of Electrical Energy Storage Systems.
B. Analyze the performance of various Electrical Energy Storage Systems.
C. Assess the markets for the Electrical Energy Storage Systems.

Syllabus Contents:
The Role of Electrical Energy Storage Technologies in Electricity use. Emerging needs of Electrical Energy Storage (EES), The roles of EES, Types of Electrical Energy Storage Systems, Classification, Mechanical, Electrochemical, Chemical, Electrical, Thermal Energy Storage systems, Standards and Safety involved, Areas of applications of EES, Markets and forecast for EES.

References:

1. IEC White paper on Electrical Energy Systems:
i. *www.iec.ch/whitepaper/pdf/iecWP*
2. Energy Storage Systems, Volume I and II, EOLSS, *www. eolssunesco@gmail.com*
3. Energy Storage for Power Systems, A. G. Ter-Gazarian, Institution of Engineering and Technology, 2011..

BIG DATA ANALYSIS

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
100 marks: Continuous evaluation-
Assignment/Quizzes – 40 marks
End Sem Exam - 60 marks

Unit 1 **[05 Hrs]**

Fundamental of Business Analytics

Learning Objectives; What Is Business Analytics?, Evolution of Business Analytics, Scope of Business Analytics, Data for Business Analytics, Decision Models, Problem Solving and Decision Making, Spreadsheet Modeling and Spreadsheet Engineering.

Unit 2 **[07 Hrs]**

Descriptive Analytics

Visualizing and Exploring Data: Data Visualization, Data Queries Using Sorting and Filtering, Statistical Methods for Summarizing Data, Descriptive Statistical Measures: Populations and Samples, Measures of Location, Measures of Dispersion, Measures of Shape, Measures of Association, Statistical Thinking in Business Decisions, Details of Data Modeling.

Unit 3 **[07 Hrs]**

Predictive Analytics

Predictive Modeling and Analysis: Logic-Driven Modeling, Data-Driven Modeling, Analyzing Uncertainty and Model Assumptions, Model Analysis Using Risk Solver Platform, Introduction to Data Mining: The Scope of Data Mining, Data Exploration and Reduction, Classification, Classification Techniques, Association Rule Mining, Cause-and-Effect Modeling

Unit 4 **[07 Hrs]**

Prescriptive Analytics

Linear Optimization: Building Linear Optimization Models, Implementing Linear Optimization Models on Spreadsheets, Solving Linear Optimization Models, Graphical Interpretation of Linear Optimization, Using Optimization Models for Prediction and Insight, Applications of Linear Optimization: Types of Constraints in Optimization Models

Unit 5 **[06 Hrs]**

Making Decisions

Making Decisions with Uncertain Information, Decision Trees, The Value of Information, Utility and Decision Making, Case Study

Outcomes:

This course aims at

1. Describe and interpret the basic concepts of Business Analytics (BA).
2. Describe basic principles of data mining as a basic tool of Business Analytics.
3. Evaluate business problems and determine suitable analytical methods.
4. Evaluate the difficulties presented by massive, opportunistic data.
5. Plan, organize and evaluate methods to prepare raw data for business analytics, including partitioning data and imputing missing values.
6. Compare and contrast different BA techniques.
7. Interpret, analyze and validate the results.
8. Synthesis the types of questions Business Analytics using data mining can be answered.
9. Evaluate different methods of data mining and how they compare.

High Voltage Engineering Lab

Teaching Scheme:
Lectures: 2 hrs/week
Practical: 2 hrs/week

Examination Scheme:
100 marks: Continuous evaluation-
Practical/ Oral Exam: 50 marks
Term work: 50 marks
(Quiz/Test/Assignments)

Unit 1 **[05 hrs]**

Breakdown in Gases:

Breakdown in Uniform gap, non-uniform gaps, Townsend's theory, Streamer mechanism, Corona discharge

Unit 2 **[04 hrs]**

Breakdown in liquid and solid Insulating materials:

Breakdown in pure and commercial liquids, Solid dielectrics and composite dielectrics, intrinsic breakdown, electromechanical breakdown and thermal breakdown, Partial discharge, applications of insulating materials.

Unit 3 **[04 hrs]**

Generation of High Voltages:

Generation of high voltages, generation of high alternating voltages, generation of impulse voltages, generation of impulse currents, tripping and control of impulse generators.

Unit 4 **[04 hrs]**

Measurements of High Voltages and Currents:

Peak voltage, impulse voltage and high direct current measurement method, cathode ray oscillographs for impulse voltage and current measurement, measurement of dielectric constant and loss factor, partial discharge measurements

Unit 5 **[03 hrs]**

Design, Planning & Layout of H. V. Laboratories:

High voltage laboratory layout, indoor and outdoor laboratories, testing facility requirements, High Voltage laboratories all over the world

Unit 6 **[04 hrs]**

High Voltage Testing of Electrical Apparatus:

Various standards for HV Testing of electrical apparatus, IS, ANSI, IEC standards, Testing of insulators and bushings, testing of isolators and circuit breakers, testing of cables, power transformers and some high voltage equipments.

List of Experiments:

1. To study the use of Sphere gap as a Voltmeter for measurement of High Voltages
2. To measure the Dielectric strength of air
3. To study the breakdown under Uniform and non-uniform fields
4. To measure the breakdown strength of Liquid dielectrics as per I. S.
5. To study the effect of gap-length on B. D. strength of Liquid dielectrics
6. To measure the breakdown strength of various solid dielectrics
7. To study the breakdown of Composite dielectrics
8. To perform High voltage withstand test on Cables/ Safety gloves/ Safety shoes etc.
9. To study the flashover phenomenon
10. To simulate Corona discharge
11. To study Horn-gap surge diverter
12. To study Impulse generator
13. Visit to Substation / Special purpose high voltage laboratory

(Minimum ten experiments out of the above mentioned list to be performed)

Text Books:

- High Voltage Engineering by M. S. Naidu, V. Kamaraju, Tata McGraw Hill Publication Co. Ltd New Delhi, 2013, ISBN-978-1-25-906289-6
- High Voltage Engineering by C. L. Wadhwa, New Age International Publishers Ltd.
- High Voltage Engineering by Prof. D. V. Razevig Translated from Russian by Dr. M. P. Chourasia Khanna Publishers, New Delhi

Reference Book:

- High Voltage Engineering Fundamentals by E. Kuffel, W. S. Zaengl, J. KuffelNewnes Publication, ISBN-0-7506-3634-3
- High Voltage and Electrical Insulation Engineering by Ravindra Arora, WolfGang Mosch New Age International Publishers Ltd. Wiley Eastern Ltd., ISBN-978-0-470-60961-3
- Various IS standards for HV Laboratory Techniques and Testing

Outcomes:

At the end of this course students will demonstrate the ability to:

- Propose the proper insulating medium / system; based on the insulation strength of the material for applying to high voltage systems.
- Measure the high voltages and currents.
- Design the high voltage laboratory and the equipment installations in it.
- Carry out HV tests on various equipments e. g. Cables, CBs, Insulators etc, using relevant testing IS and be able to give analysis of the test results.

ELECTRICAL MINOR

Power Converters

Teaching Scheme
Lectures: 3 hrs/week
Tutorial : ----

Examination Scheme
100 marks: Continuous evaluation-
Assignments /Quiz- 40 Marks,
End - Sem Exam – 60 Marks

Unit 1 **[08 hrs]**

Power electronic systems:

An overview of Power Electronics Devices, Their turn on and turn of characteristics, protection of devices and circuits, Operation of series connected devices, Uncontrolled and controlled rectifier.

Unit 2 **[08 hrs]**

Inverters:

Introduction, Classification of inverters, Single phase parallel capacitor inverter, voltage source inverters, PWM voltage source inverter, current source inverter, Multilevel inverters.

Unit 3 **[08 hrs]**

Ac voltage controllers and cycloconverters:

Types of ac voltage controllers, Single phase controllers, sequence control of ac voltage

controllers, Principle of cycloconverter operation, single phase step up and step down cycloconverter, three phase cycloconveter.

Unit 4 **[06 hrs]**

DC to dc converters:

Working principle, analysis and design of: Buck converter, boost converter, buck-boost converter, Cuk converter, PWM control for dc-dc converter**.**

Unit 5 **[06 hrs]**

Design of switching converters:

Design of different switching converters, Design of Power circuit, Design of filter circuit, Design of Control circuit, Design of compensator, Simulation of switching converters.

Unit 6 **[06 hrs]**

Industrial applications of power converters:

Switched mode power supply, Uninterruptible power supplies, static switches, static circuit breakers, solid state relays, ac and dc drives.

Text Books

- N.Mohan,T.M. Undeland and W.P.Robbins,"Power Electronics: Converter, Applications and Design", John Wiley and Sons, 1989.
- M.H. Rashid,"Power Electronics", Prentice Hall of India, 1994.

Reference Book

2. S B.K.Bose, "Power Electronics and A.C. Drives", Prentice Hall, 1986.
3. V.R. Moorthi, "Power Electronics, Devices, circuits, and industrial applications" Oxford press.

Outcomes:

At the end of this course students will demonstrate the ability to:

- Present detailed analysis on rectifier topologies.
- Provide comprehensive analysis of voltage and current source inverter topologies.
- Provide comprehensive analysis of voltage controllers.
- Design different dc-dc converter and their control.
- Implement and illustrates applications of power converters

RENEWABLE MINOR

Hydro Energy Systems

Teaching Scheme:
Lectures: 3 hrs/week
Field Visit: As necessary

Examination Scheme:
MCQ-1 and 2: 20 Marks each
End-Semester Exam: 60 Marks

Unit 1 **[06 Hrs]**

Basics of Hydro Energy and is Availability:

Energy in water, basic hydro energy conversion, energy conversion calculations and efficiency, categorization of hydroelectric power plants, viz. micro, small and large, decentralized hydroelectric plants, types of turbines and their applications in small hydro technologies, site requirements for hydro power, availability of sites globally and in India, environmental impact of various capacity hydroelectric plants.

Unit 2 **[06 Hrs]**

Introduction to Small Hydro Power Technologies:

Scale of turbines being considered, technologies for small hydro, turbine designs and efficiencies, control systems, safety, design considerations for a small hydro power plant, components of small hydro power plants, stand alone and grid interactive plants, operation and maintenance, standards and certification, manufacturing, quality assurance and testing .

Unit 3 **[08 Hrs]**

Kinetic Energy Turbines:

What are kinetic energy turbines, state of the art technologies, design considerations and materials, testing, site requirements, marine current turbines, in pipe turbines, typical designs for generators, power plants, decentralized hydroelectric plants, modular configuration, environmental impact .

Unit 4 **[08 Hrs]**

Small Hydro Power Plants:

Typical design of small hydro power plants, design considerations for components, decentralized plants, generator designs, operation and maintenance, site requirements, environmental impact assessment, manufacturing and assembly, quality assurance, standards and certification .

Unit 5 **[08 Hrs]**

Economics of Small Hydro Power Plants:

Cost of small hydro power plants, technology wise difference in costing, site development costs, environmental impact costs, life cycle costing, return on investment; impact of scale on the economics

Unit 6 **[06 Hrs]**

Field Visits:

One or more of the following visits may be undertaken.
Small scale hydro electricity generator system manufacturer
Small hydro power plant either stand alone or grid connected
Manufacturer of electronics and control systems for small hydro

Reference Books:

- Trainer's Textbook, Small Hydro Power (SHP) Module, Ministry of New and Renewable Energy, Government of India
- Standards / Manuals / Guidelines for Small Hydro Power Development (General 2012, Civil Work 2008), Ministry of New and Renewable Energy, Government of India
- Small Hydro Handbook, Colorado Energy Office, Denver Colorado, USA
- Small Hydro Power Plants in Europe: Handbook on Administrative Procedures Requested, Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb, Croatia, 2009
- Layman's Guidebook on How to Develop Small Hydro Site, European Small Hydropower Association, Brussels, Belgium, 1998
- Handbook of Innovative technologies to Promote SHP, Final Version, European Union, Report on Work Package V, Common Strategies to Improve SHP Implementation, 2011

Course Outcomes:

Students will be able to:

- Understand the basics of hydro energy, availability, applications, various types of small hydro power plants, engineering required for small hydro power plants, environmental impact considerations, introduction to manufacturing of the systems, characterization, quality assurance, standards, certification and economics.
- A field visits will be designed for firsthand experience and demonstration of the system elements.
- Know and recall core knowledge of the syllabus. (To measure this outcome, questions may be of multiple choice type or of the type-define, identify, state, match, list, name etc.)
- Understand basic concepts. (To measure this outcome, questions may be of the type explain, describe, illustrate, evaluate, give examples, compute etc.)

Annexure-II:

Sample list of Liberal Learning courses offered at Institute level
Course Outcome:
Student will be able to choose and enhance practical learning and application in the subject of his/her choice.

One credit course spread over the semester to enhance practical learning and application

1. **Agriculture (**Landscaping, Farming, etc.**)**
2. **Business (**Management, Entrepreneurship, etc.**)**
3. **Defence (**Study about functioning of Armed Forces**)**
4. **Education (**Education system, Policies, Importance, etc.**)**
5. **Fine Arts (**Painting, Sculpting, Sketching, etc.**)**
6. **Linguistics**
7. **Medicine and Health (**Diseases, Remedies, Nutrition, Dietetics, etc.**)**
8. **Performing Arts (**Music, Dance, Instruments, Drama, etc.**)**
9. **Philosophy**
10. **Social Sciences (**History, Political Sc., Archaeology, Geography, Civics, Economics, etc.**)**