# ACADEMIC REGULATIONS
# COURSE STRUCTURE AND
# DETAILED SYLLABUS

## ELECTRICAL & ELECTRONICS ENGINEERING

*For*

## M. Tech. (Power Electronics & Industrial Drives)

(Three Year **Part Time** Programme)

**JNTUH COLLEGE OF ENGINEERING HYDERABAD**
**(Autonomous)**
Kukatpally, Hyderabad – 500 085, Telangana, India.

**2016**

**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD**
**COLLEGE OF ENGINEERING HYDERABAD**
**(AUTONOMOUS)**
**Kukatpally, Hyderabad – 500 085**

# ACADEMIC REGULATIONS 2015

## for CBCS Based M.Tech. (Part- Time) Programmes

(Effective for the students admitted into I year from the Academic Year **2016-17** and onwards)

**1.0 Part-Time Post-Graduate Degree Programmes in Engineering & Technology (PTPGP in E & T):**

JNTUH offers 3 Year (6 Semesters) Part-time **Master of Technology** (M.Tech.) Degree Programmes, under Choice Based Credit System (CBCS) at its Constituent Autonomous College - JNTUH College of Engineering Hyderabad with effect from the Academic Year 2016 - 17 onwards in the different branches of Engineering & Technology with different specializations.

**2.0 Eligibility for Admission:**

2.1 Admissions to the PTPGPs shall be made subject to the eligibility, qualifications and specializations prescribed by JNTUH College of Engineering Hyderabad, JNT University Hyderabad, for each Specialization under each M.Tech. Programme, from time to time.

2.2 Admission to the PTPGP shall be made either on the basis of the Merit Rank obtained by the qualifying candidate at an Entrance Test conducted by the Jawaharlal Nehru Technological University Hyderabad / on the basis of any other order of merit approved by the University, subject to reservations as prescribed by the Government from time to time.

2.3 Candidates seeking admission to programmes on a part time basis should be working in or around the place where the programme is being run after passing the qualifying examination.

2.4 The medium of instructions for all PG Programmes will be ENGLISH only.

**3.0 M.Tech. Programme (PTPGP in E & T) Structure:**

3.1 The M.Tech. Programmes in E & T of JNTUH-CEH are of Semester Pattern, with 6 Semesters constituting 3 Academic Years, each Academic Year having TWO Semesters (First/Odd and Second/Even Semesters). Each Semester shall be of 22 Weeks duration (inclusive of Examinations), with a minimum of 90 Instructional Days per Semester.

3.2 UGC/ AICTE specified Definitions/ Descriptions are adopted appropriately for various terms and abbreviations used in these PTPGP - Academic Regulations.

3.2.1 **Semester Scheme:**

Each Semester having - 'Continuous Internal Evaluation (CIE)' and 'Semester End Examination (SEE)'. Choice Based Credit System (CBCS) and Credit Based Semester System (CBSS) as denoted are taken as 'references' for the present set of Regulations. The terms 'SUBJECT' or 'COURSE' imply the same meaning here, and refer to 'Theory Subject', or 'Lab Course', or 'Design/ Drawing Subject', or 'Seminar', or 'Comprehensive Viva', or 'Project', as the case may be.

3.2.2 **Credit Courses:**

All Subjects (or Courses) are to be registered by a student in a Semester to earn Credits. Credits shall be assigned to each Subject/ Course in a L: T: P: C (Lecture Periods: Tutorial Periods: Practicals Periods : Credits) Structure, based on the following general pattern …

- One hour/ Week/ Semester for Theory/ Lecture (L) Courses; and,
- Two hours/ Week/ Semester for Laboratory/ Practical (P) Courses or Tutorials (T).

Other student activities like Study Tour, Guest Lecture, Conference/ Workshop Participations, Technical Paper Presentations etc., and identified Mandatory Courses if any, will not carry Credits.

3.2.3 **Subject/ Course Classification:**

All Subjects/ Courses offered for the PTPGP are broadly classified as : (a) Core Courses (CoC), and (b) Elective Courses (EℓC).

- Core Courses (CoC) and Elective Courses (EℓC) are categorized as PS (Professional Subjects), which are further subdivided as – (i) PC (Professional/ Departmental Core) Subjects, (ii) PE (Professional/ Departmental Electives) , (iii) Seminar, (iv) Comprehensive Viva, and (v) Project Work (PW).

3.2.4 **Course Nomenclature:**

The Curriculum Nomenclature or Course-Structure Grouping for the M.Tech. Degree Programmes is as listed below …

| ***S. No.*** | ***Broad Course Classification*** | ***Course Group/ Category*** | ***Courses Description*** | ***Credits*** |
|---|---|---|---|---|
| 1) | Core Courses (CoC) | PC- Professional Core | Includes core subjects related to the Parent Discipline/ Department/ Branch of Engg. | 20 |
| 2) | Elective Courses (EℓC) | PE– Professional Electives | Includes Elective subjects related to the Parent Discipline/ Department/ Branch of Engg. | 32 |
| 3) | Core Courses | Project Work | M.Tech. Project or PG Project or PG Major Project | 30 |
| | | Seminar | Seminar/ Colloquium based on core contents related to Parent Discipline/ Department/ Branch of Engg. | 2 |
| | | Comprehensive Viva-voce | Viva-voce covering all the PG Subjects and related aspects | 4 |
| | | Communication Skills/ Soft Skills | Lab oriented | 2 |
| **Total Credits for PTPGP** | | | | **90** |

**4.0 Course Work:**

4.1 A Student, after securing admission, shall pursue and complete the M.Tech. PTPGP in a minimum period of 3 Academic Years (6 Semesters), and within a maximum period of 6 Academic Years (starting from the Date of Commencement of I Year).

4.2 Each student shall Register for and Secure the specified number of Credits required for the completion of the PTPGP and Award of the M.Tech. Degree in respective Branch of Engineering with the chosen Specialization.

4.3 I &II Year is structured to provide typically 14 Credits (14 C) in each of the I and II Semesters, and III Year comprises of 34 Credits (34 C), totaling to 90 Credits (90 C) for the entire M.Tech. Programme.

**5.0 Course Registration:**

5.1 A 'Faculty Advisor' shall be assigned to each M.Tech. Programme with respective Specialization, who will advise the Students about the M.Tech. Programme Specialization, its Course Structure and Curriculum, Choice/ Option for Subjects/ Courses, based on his competence, progress, pre-requisites and interest.

5.2 A Student may be permitted to Register for Subjects/ Courses of 'his CHOICE' with a typical total of 14 Credits per Semester in I &II Year (Minimum being 10 C and Maximum being 18 C, and 16 Credits (inclusive of Project) per V Semester in III Year (Minimum being 16 C and Maximum being 30 C), 18 credits (inclusive of Project) per VI Semester in III Year (minimum being 18 C and maximum 32 C), based on his interest, competence, progress, and 'PRE-REQUISITES' as indicated for various Subjects/ Courses, in the Department Course Structure (for the relevant Specialization) and Syllabus contents for various Subjects/ Courses.

5.3 Choice for 'additional Subjects/ Courses' in any Semester (above the typical 14/16/18 Credit norm, and within the Maximum Permissible Limit of 16/30/32 Credits, during I&II/ III Years as applicable) must be clearly indicated in the Registration, which needs the specific approval and signature of the Faculty Advisor/ Counselor on hard-copy.

5.4 Dropping of Subjects/ Courses in any Semester of I Year or II year may be permitted, ONLY AFTER obtaining prior approval and signature from the Faculty Advisor (subject to retaining a minimum of 10 Credits), 'within 15 Days of Time' from the beginning of the current Semester.

6.0 Subjects/Courses to be offered

6.1 A typical Section(or Class) sanctioned strength for each semester shall be 30.

6.2 A Subject/Course may be offered to the students ONLY if Minimum of 15 (1/2 of Section Strength) opt for the same. The Maximum strength of a Section is limited to 45(30+1/2 of the Section Strength).

**7.0 Attendance Requirements:**

7.1 A Student shall be eligible to appear for the End Semester Examination (SEE) of any Subject, if he acquires a minimum of 75% of attendance in that Subject for that Semester.

7.2 A Student's Seminar Report and Seminar Presentation shall be eligible for evaluation, only if he ensures a minimum of 75% of his attendance in Seminar Presentation Classes during that Semester.

7.3 Condoning of shortage of attendance up to 10% (65% and above, and below 75%) in each Subject or Seminar of a Semester may be granted by the College Academic Council on genuine and valid grounds, based on the Student's representation with supporting evidence.

7.4 A stipulated fee per Subject/Seminar shall be payable towards condoning of shortage of attendance.

7.5 Shortage of Attendance below 65% in any Subject/Seminar shall in NO case be condoned.

7.6 A Student, whose shortage of attendance is not condoned in any Subject(s) or Seminar in any Semester, is considered as 'Detained in that Subject(s)/ Seminar', and is not eligible to take End Examination(s) of such Subject(s) (and in case of Seminars, his Seminar Report or Presentation are not eligible for evaluation) in that Semester; and he has to seek Re-registration for those Subject(s)/Seminar in subsequent Semesters, and attend the same as and when offered.

**8.0 Academic Requirements:**

The following Academic Requirements have to be satisfied, in addition to the Attendance Requirements mentioned in Item No. 7**.**

8.1 A Student shall be deemed to have satisfied the Academic Requirements and earned the Credits allotted to each Subject/ Course, if he secures not less than 40% Marks (28 out of 70 Marks) in the End Semester Examination, and a minimum of 50% of Marks in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together; in terms of Letter Grades, this implies securing B Grade or above in that Subject.

8.2 A Student shall be deemed to have satisfied the Academic Requirements and earned the Credits allotted to - Seminar, and Comprehensive Viva-voce, if he secures not less than 50% of the total Marks to be awarded for each. The Student would be treated as failed, if he - (i) does not attend the Comprehensive Viva-voce as per the schedule given, or (ii) does not present the Seminar as required, or (ii) secures less than 50% of Marks ( < 50 Marks) in -Seminar/ Comprehensive Viva-voce evaluations.
He may reappear for comprehensive viva where it is scheduled again; For seminar, he has to reappear in the next subsequent Semesters, as and when scheduled.

8.3 A Student shall - register for all Subjects covering 90 Credits as specified and listed in the Course Structure for the chosen PTPGP Specialization, put up all the Attendance and Academic requirements for securing 90 Credits obtaining a minimum of B Grade or above in each Subject, and 'earn all 90 Credits securing SGPA $\geq$ 6.0 ( in each Semester) and final CGPA (ie., CGPA at the end of PTPGP) $\geq$ 6.0, to successfully complete the PTPGP.

8.4 Marks and Letter Grades obtained in all those Subjects covering the above specified 90 Credits alone shall be considered for the calculation of final CGPA, which shall be indicated in the Grade Card of III Year II Semester.

8.5 If a student registers for some more 'extra Subjects' (in the parent Department or other Departments/Branches of Engg.) other than those listed Subjects totaling to 90 Credits as specified in the Course Structure, the performances in those 'extra Subjects' (although evaluated and graded using the same procedure as that of the required 90 Credits) will not be taken into account while calculating the SGPA and CGPA. For such 'extra Subjects' registered, % marks and Letter Grade alone will be indicated in the Grade Card, as a performance measure, subject to completion of the Attendance and Academic Requirements as stated in Items 7 and 8.1 – 8.4 above.

8.6 Students who fail to earn 90 Credits as per the specified Course Structure, and as indicated above, within 6 Academic Years from the Date of Commencement of their I Year, shall forfeit their seats in M.Tech. Programme and their admissions shall stand cancelled.

8.7 When a Student is detained due to shortage of attendance in any Subject(s)/Seminar in any Semester, no Grade Allotment will be done for such Subject(s)/Seminar, and SGPA/ CGPA calculations of that Semester will not include the performance evaluations of such Subject(s)/Seminar in which he got detained. However, he becomes eligible for re-registration of such Subject(s)/Seminar (in which he got detained) in the subsequent Semester(s), as and when next offered, with the Academic Regulations of the Batch into which he gets readmitted, by paying the stipulated fees per Subject. In all these re-registration cases, the Student shall have to secure a fresh set of Internal Marks (CIE) and End Semester Examination Marks (SEE) for performance evaluation in such Subject(s), and subsequent SGPA/ CGPA calculations.

8.8 A Student eligible to appear in the End Semester Examination in any Subject, but absent at it or failed (failing to secure B Grade or above), may reappear for that Subject at the supplementary examination (SEE) as and when conducted. In such cases, his Internal Marks (CIE) assessed earlier for that Subject/ Course will be carried over, and added to the marks to be obtained in the supplementary examination (SEE), for evaluating his performance in that Subject.

## 9.0 Evaluation - Distribution and Weightage of Marks:

9.1 The performance of a Student in each Semester shall be evaluated Subject-wise (irrespective of Credits assigned) with a maximum of 100 Marks for Theory or Practicals or Seminar or Drawing/Design or Comprehensive Viva-voce etc; however, the M.Tech. Project Work (Major Project) will be evaluated for 200 Marks.

9.2 a) For Theory Subjects, CIE Marks shall comprise of - Mid-Term Examination Marks (for 25 Marks), and Assignment Marks (for 5 Marks).

b) During the Semester, there shall be 2 Mid-Term examinations. Each Mid-Term examination shall be for 25 Marks (with 120 minutes duration). The better performance out of these two Mid-Term Examinations shall be considered for the award of 25 Marks.

9.3 For Practical Subjects, there shall be a Continuous Internal Evaluation (CIE) during the Semester for 30 Internal Marks, and 70 Marks are assigned for

Lab./Practicals End Semester Examination (SEE). Out of the 30 Marks for Internals, day-to-day work assessment in the laboratory shall be evaluated for 20 Marks; and the performance in an internal Lab./Practical Test shall be evaluated for 10 marks. The SEE for Lab./ Practicals shall be conducted at the end of the Semester by the concerned Lab. Teacher and another faculty member of the same Department as assigned by the Head of the Department.

9.4 There shall be a Seminar Presentation in II Year I(III) Semester or II(IV ) Semester. For the Seminar, the Student shall collect the information on a specialized topic, prepare a Technical Report and submit to the Department at the time of Seminar Presentation. The Seminar Presentation (along with the Technical Report) shall be evaluated by Two Faculty Members assigned by Head of the Department, for 100 Marks. There shall be no SEE or External Examination for Seminar.

9.5 Each Student shall appear for a Comprehensive Viva-Voce at the end of the V Semester (III Year I Semester). The Comprehensive Viva-Voce shall be conducted by a Committee, consisting of three senior faculty members of Department nominated by the Head of the Department, and the performance evaluation shall be for 100 Marks. There are no Internal Marks for the Comprehensive Viva-Voce.

9.6 a) Every PTPGP Student shall be required to execute his M.Tech. Project, under the guidance of the Supervisor assigned to him by the Head of Department. The PTPGP Project shall start immediately after the completion of the II Year II(IV) Semester, and shall continue through III Year I (V) and II (IV) Semesters. The Student shall carry out the literature survey, select an appropriate topic and submit a Project Proposal within 6 weeks (immediately after his II Year II Semester (IV) End Examinations), for approval by the Project Review Committee (PRC). The PRC shall be constituted by the Head of Department, and shall consist of the Head of Department, Project Supervisor, and a Senior Faculty Member of the Department. The Student shall present his Project Work Proposal to the PRC (PRC-I Presentation), on whose approval he can 'REGISTER for the PG Project'. Every Student must compulsorily register for his M.Tech. Project Work, within the 6 weeks of time-frame as specified above. After Registration, the Student shall carry out his work, and continually submit 'a fortnightly progress report' to his Supervisor throughout the Project period. The PRC will monitor the progress of the Project Work and review, through PRC-II and PRC-III Presentations – one at the end of the III Year I (V) Semester, and one before the submission of M.Tech. Project Work Report/ Dissertation.

b) After PRC-III presentation, the PRC shall evaluate the entire performance of the Student and declare the Project Report as 'Satisfactory' or 'Unsatisfactory'. Every Project Work Report/ Dissertation (that has been declared 'satisfactory') shall undergo 'Plagiarism Check' as per the University/ College norms to ensure content plagiarism below a specified level of 30%, and to become acceptable for submission. In case of unacceptable plagiarism levels, the student shall resubmit the Project Work Report, after carrying out the necessary modifications/ additions to his Project Work/ Report as per his Supervisor's advice, within the specified time, as suggested by the PRC.

c) If any Student could not be present for PRC-II at the scheduled time (after approval and registration of his Project Work at PRC-I), his submission

and presentation at the PRC-III time (or at any other PRC specified dates) may be treated as PRC-II performance evaluation, and delayed PRC-III dates for him may be considered as per PRC recommendations. Any Student is allowed to submit his M.Tech. Project Dissertation 'only after completion of 40 weeks from the date of approval/registration' of his Project, and after obtaining all approvals from the PRC.

d) A total of 200 Marks are allotted for the M.Tech. Project Work, ( out of which 100 Marks are allotted for internal evaluation and 100 Marks for external evaluation). For internal Evaluation of 100 marks, Project Supervisor shall evaluate for 60 marks based on the continuous Internal Evaluation(CIE) of the student's performance and combined PRC-I, II & III performance evaluation will be for 40 marks (to be awarded by PRC, as SEE).

9.7 a) The Student shall be allowed to submit his Project Dissertation, only on the successful completion of all the prescribed PG Subjects (Theory and Labs.), Seminar, Comprehensive Viva-voce etc. (securing B Grade or above), and after obtaining all approvals from PRC. In such cases, the M.Tech. Dissertations will be sent to an External Examiner nominated by the Principal of the College, on whose 'approval', the Student can appear for the M.Tech. Project Viva-voce Examination, which shall be conducted by a Board, consisting of the PG Project Supervisor, Head of the Department, and the External Examiner who adjudicated the M.Tech. Project Work and Dissertation. The Board shall jointly declare the Project Work Performance as 'satisfactory', or 'unsatisfactory'; and in successful cases, the External Examiner shall evaluate the Student's Project Work presentation and performance for 100 Marks (SEE).

b) If the adjudication report of the External Examiner is 'not favourable' , then the Student shall revise and resubmit his Dissertation after one Semester, or as per the time specified by the External Examiner and/ or the PRC. If the resubmitted report is again evaluated by the External Examiner as 'not favourable', then that Dissertation will be summarily rejected. Subsequent actions for such Dissertations may be considered, only on the specific recommendations of the External Examiner and/ or PRC.

c) In cases, where the Board declared the Project Work Performance as 'unsatisfactory', the Student is deemed to have failed in the Project Viva-voce Examination, and he has to reappear for the Viva-voce Examination as per the Board recommendations. If he fails in the second Viva-voce Examination also, he will not be considered eligible for the Award of the Degree, unless he is asked to revise and resubmit his Project Work by the Board within a specified time period (within 6 years from the date of commencement of his I Year I Semester).

**10.0 Re-Admission / Re-Registration:**

10.1 **Re-Admission for Discontinued Students:**

Students, who have discontinued the M.Tech. Degree Programme due to any reasons what so ever, may be considered for 'Readmission' into the same Degree Programme (with same specialization) with the Academic Regulations of the Batch into which he gets readmitted, with prior permission from the concerned authorities, subject to Item 4.1.

**10.2 Re-Registration for Detained Students:**

When any Student is detained in a Subject (s)/ Seminar due to shortage of attendance in any Semester, he may be permitted to re-register for the same Subject in the 'same category' (Core or Elective Group) or equivalent Subject if the same Subject is not available, as suggested by the Board of Studies of that Department, as when offered in the sub-sequent Semester(s), with the Academic Regulations of the Batch into which he seeks re-registration , with prior permission from the concerned authorities, subject to Item 4.1.

**11.0 Grading Procedure:**

11.1 Marks will be awarded to indicate the performance of each student in each Theory Subject, or Lab/Practicals, or Seminar, or Project, etc., based on the % marks obtained in CIE + SEE (Continuous Internal Evaluation + Semester End Examination, both taken together) as specified in Item 6 above, and a corresponding Letter Grade shall be given.

11.2 As a measure of the student's performance, a 10-point Absolute Grading System using the following Letter Grades (UGC Guidelines) and corresponding percentage of marks shall be followed:

| *% of Marks Secured (Class Intervals)* | *Letter Grade (UGC Guidelines)* | *Grade Points* |
|---|---|---|
| 80% and above ( ≥ 80% , ≤ 100% ) | O (Outstanding) | 10 |
| Below 80% but not less than 70% ( ≥ 70% , < 80% ) | $A^+$ (Excellent) | 9 |
| Below 70% but not less than 60% ( ≥ 60% , < 70% ) | A (Very Good) | 8 |
| Below 60% but not less than 55% ( ≥ 55% , < 60% ) | $B^+$ (Good) | 7 |
| Below 55% but not less than 50% ( ≥ 50% , < 55% ) | B (above Average) | 6 |
| Below 50% ( < 50% ) | F (FAIL) | 0 |
| **Absent** | **Ab** | **0** |

11.3 A student obtaining F Grade in any Subject shall be considered 'failed' and is be required to reappear as 'Supplementary Candidate' in the Semester End Examination (SEE), as and when offered. In such cases, his Internal Marks (CIE Marks) in those Subjects will remain the same as those he obtained earlier.

11.4 A Letter Grade does not imply any specific % of Marks.

11.5 A student earns Grade Point (GP) in each Subject/ Course, on the basis of the Letter Grade obtained by him in that Subject/ Course (excluding Mandatory non-credit Courses). Then the corresponding 'Credit Points' (CP) are computed by multiplying the Grade Point with Credits for that particular Subject/ Course.

**Credit Points (CP) = Grade Point (GP) x Credits …. For a Course**

11.6 The Semester Grade Point Average (SGPA) is calculated by dividing the Sum of Credit Points (ΣCP) secured from ALL Subjects/ Courses registered in a Semester,

by the Total Number of Credits registered during that Semester. SGPA is rounded off to TWO Decimal Places. SGPA is thus computed as

**SGPA = { $\sum_{i=1}^{N} C_i G_i$ } / { $\sum_{i=1}^{N} C_i$ } …. For each Semester**,

where 'i' is the Subject indicator index (takes into account all Subjects in a Semester), 'N' is the no. of Subjects 'REGISTERED' for the Semester (as specifically required and listed under the Course Structure of the parent Department), $C_i$ is the no. of Credits allotted to the $i^{th}$ Subject, and $G_i$ represents the Grade Points (GP) corresponding to the Letter Grade awarded for that $i^{th}$ Subject.

11.7 The Cumulative Grade Point Average (CGPA) is a measure of the overall cumulative performance of a student over all Semesters considered for registration. The CGPA is the ratio of the Total Credit Points secured by a student in ALL registered Courses in ALL Semesters, and the Total Number of Credits registered in ALL the Semesters. CGPA is rounded off to TWO Decimal Places. CGPA is thus computed from the I Year second Semester onwards, at the end of each Semester, as per the formula

**CGPA = { $\sum_{j=1}^{M} C_j G_j$ } / { $\sum_{j=1}^{M} C_j$ } … for all S Semesters registered (ie., upto and inclusive of S Semesters, S ≥ 1 )**,

where 'M' is the TOTAL no. of Subjects (as specifically required and listed under the Course Structure of the parent Department) the Student has 'REGISTERED' from the 1st Semester onwards upto and inclusive of the Semester S ( obviously M > N ), 'j' is the Subject indicator index (takes into account all Subjects from 1 to S Semesters), $C_j$ is the no. of Credits allotted to the $j^{th}$ Subject, and $G_j$ represents the Grade Points (GP) corresponding to the Letter Grade awarded for that $j^{th}$ Subject. After registration and completion of I Year I Semester however, the SGPA of that Semester itself may be taken as the CGPA, as there are no cumulative effects.

11.8 For Merit Ranking or Comparison Purposes or any other listing, ONLY the 'ROUNDED OFF' values of the CGPAs will be used.

11.9 For Calculations listed in Item 11.5 – 11.8, performance in failed Subjects/ Courses (securing F Grade) will also be taken into account, and the Credits of such Subjects/ Courses will also be included in the multiplications and summations. However, Mandatory Courses will not be taken into consideration.

11.10 A student shall be declared successful or 'passed' in a Semester, only when he gets a SGPA ≥ 6.00 (at the end of that particular Semester); and a student shall be declared successful or 'passed' in the entire PGP, only when gets a CGPA ≥ 6.00; subject to the condition that he secures a GP ≥ 6 (B Grade or above) in every registered Subject/ Course in each Semester (during the entire PGP) for the Degree Award, as required.

11.11 After the completion of each Semester, a Grade Card or Grade Sheet (or Transcript) shall be issued to all the Registered Students of that Semester, indicating the Letter Grades and Credits earned. It will show the details of the Courses Registered (Course Code, Title, No. of Credits, Grade Earned etc.), Credits earned, SGPA, and CGPA.

**11.12 Passing Standards :**

11.12.1 A Student shall be declared successful or 'passed' in a Semester, only when he gets a SGPA ≥ 6.00 (at the end of that particular Semester); and a Student shall be declared successful or 'passed' in the entire PGP, only when gets a CGPA ≥ 6.00; subject to the condition that he secures a GP ≥ 6 (B Grade or above) in every registered Subject/ Course in each Semester (during the entire PGP), for the Award of the Degree, as required.

11.12.2 After the completion of each Semester, a Grade Card or Grade Sheet (or Transcript) shall be issued to all the Registered Students of that Semester, indicating the Letter Grades and Credits earned. It will show the details of the Courses Registered (Course Code, Title, No. of Credits, Grade Earned), Credits earned, SGPA, and CGPA etc.

**12.0 Declaration of Results:**

12.1 Computation of SGPA and CGPA are done using the procedure listed in 11.5 – 11.8.

12.2 For Final % of Marks equivalent to the computed CGPA, the following formula may be used ..

**% of Marks = (CGPA – 0.5) x 10**

**13.0 Award of Degree and Class:**

13.1 A Student who registers for all the specified Subjects/ Courses as listed in the Course Structure, satisfies all the Course Requirements, and passes the examinations prescribed in the entire PTPG Programme (PTPGP), and secures the required number of **90** Credits (with GP ≥ 6.0), shall be declared to have 'QUALIFIED' for the award of the M.Tech. Degree in the chosen Branch of Engineering and Technology with specialization as he admitted.

13.2 **Award of Class**

After a student has satisfied the requirements prescribed for the completion of the program and is eligible for the award of M. Tech. Degree, he shall be placed in one of the following four classes based on the % CGPA:

| Class Awarded | CGPA |
|---|---|
| First Class with Distinction | ≥ 7.75 |
| First Class | 6.75 ≤ CGPA < 7.75 |
| Second Class | 6.00 ≤ CGPA < 6.75 |

13.3 A student with final CGPA (at the end of the PTPGP) < 6.00 will not be eligible for the Award of Degree.

**14.0 Withholding of Results:**

14.1 If a Student has not paid fees to University/ College at any stage, or has pending dues against his name due to any reason whatsoever, or if any case of indiscipline is pending against him, the result of the Student may be withheld, and he will not be allowed to go into the next higher Semester. The Award or issue of the Degree may also be withheld in such cases.

## 15.0 Transitory Regulations:

15.1 A Student - who has discontinued for any reason, or who has been detained for want of attendance as specified, or who has failed after having undergone PTPGP, may be considered eligible for readmission to the same PTPGP with same set of Subjects/ Courses (or equivalent Subjects/ Courses as the case may be), and same Professional Electives (or from same set/category of Electives or equivalents as suggested), as and when they are offered (within the time-frame of 6 years from the Date of Commencement of his I Year I Semester).

## 16.0 Student Transfers:

16.1 There shall be no Branch/ Specialization transfers after the completion of Admission Process.

16.2 There shall be no transfer among the Constituent Colleges and Units of Jawaharlal Nehru Technological University Hyderabad.

## 17.0 Scope:

i) Where the words "he", "him", "his", occur in the write-up of regulations, they include "she", "her", "hers".
ii) Where the words "Subject" or "Subjects", occur in these regulations, they also imply "Course" or "Courses".
iii) The Academic Regulations should be read as a whole, for the purpose of any interpretation.
iv) In case of any doubt or ambiguity in the interpretation of the above regulations, the decision of the Vice-Chancellor/ Principal is final.
v) The College may change or amend the Academic Regulations, and/ or Course Structure, and/ or Syllabi at any time, and the changes or amendments made shall be applicable to all Students with effect from the dates as notified by the University/ College.

## 18. MALPRACTICES RULES:

| | Nature of Malpractices | Punishment |
|---|---|---|
| | **If the candidate:** | |
| 1 (a) | Possesses or keeps accessible in examination hall, any paper, note book, programmable calculators, Cell phones, pager, palm computers or any other form of material concerned with or related to the subject of the examination (theory or practical) in which he is appearing but has not made use of (material shall include any marks on the body of the candidate which can be used as an aid in the subject of the examination) | Expulsion from the examination hall and cancellation of the performance in that subject only. |
| 1 (b) | Gives assistance or guidance or receives it from any other candidate orally or by any other body language methods or communicates through cell phones with any candidate or persons in or outside the exam hall in respect of any matter. | Expulsion from the examination hall and cancellation of the performance in that subject only of all the candidates involved. In case of an outsider, he will be handed over to the police and a case is registered against him. |
| 2 | Has copied in the examination hall from any paper, book, programmable calculators, palm computers or any other form of material relevant to the subject of the examination (theory or practical) in which the candidate is appearing. | Expulsion from the examination hall and cancellation of the performance in that subject and all other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted to appear for the remaining examinations of the subjects of that Semester/year.<br>The Hall Ticket of the candidate is to be cancelled. |
| 3 | Impersonates any other candidate in connection with the examination. | The candidate who has impersonated shall be expelled from examination hall. The candidate is also debarred and forfeits the seat. The performance of the original candidate who has been impersonated, shall be cancelled in all the subjects of the examination (including practicals and project work) already appeared and shall not be allowed to appear for examinations of the remaining subjects of that semester/year. The candidate is also debarred for two consecutive semesters from class work and all examinations. The continuation of the course by the candidate is subject to the academic regulations in connection with forfeiture of seat. If the imposter is an outsider, he will be handed over to the police and a case is registered against him. |
| 4 | Smuggles in the Answer book or | Expulsion from the examination hall and |

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| | additional sheet or takes out or arranges to send out the question paper during the examination or answer book or additional sheet, during or after the examination. | cancellation of performance in that subject and all the other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the subjects of that semester/year. The candidate is also debarred for two consecutive semesters from class work and all examinations. The continuation of the course by the candidate is subject to the academic regulations in connection with forfeiture of seat. |
| 5 | Uses objectionable, abusive or offensive language in the answer paper or in letters to the examiners or writes to the examiner requesting him to award pass marks. | Cancellation of the performance in that subject. |
| 6 | Refuses to obey the orders of the Chief Superintendent / Assistant – Superintendent / any officer on duty or misbehaves or creates disturbance of any kind in and around the examination hall or organizes a walk out or instigates others to walk out, or threatens the officer-in charge or any person on duty in or outside the examination hall of any injury to his person or to any of his relations whether by words, either spoken or written or by signs or by visible representation, assaults the officer-in-charge, or any person on duty in or outside the examination hall or any of his relations, or indulges in any other act of misconduct or mischief which result in damage to or destruction of property in the examination hall or any part of the College campus or engages in any other act which in the opinion of the officer on duty amounts to use of unfair means or misconduct or has the tendency to disrupt the orderly conduct of the examination. | In case of students of the college, they shall be expelled from examination halls and cancellation of their performance in that subject and all other subjects the candidate(s) has (have) already appeared and shall not be permitted to appear for the remaining examinations of the subjects of that semester/year. The candidates also are debarred and forfeit their seats. In case of outsiders, they will be handed over to the police and a police case is registered against them. |
| 7 | Leaves the exam hall taking away answer script or intentionally tears of the script or any part thereof inside or outside the examination hall. | Expulsion from the examination hall and cancellation of performance in that subject and all the other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the subjects of that semester/year. The candidate is also |

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| | | debarred for two consecutive semesters from class work and all examinations. The continuation of the course by the candidate is subject to the academic regulations in connection with forfeiture of seat. |
| 8 | Possess any lethal weapon or firearm in the examination hall. | Expulsion from the examination hall and cancellation of the performance in that subject and all other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the subjects of that semester/year. The candidate is also debarred and forfeits the seat. |
| 9 | If student of the college, who is not a candidate for the particular examination or any person not connected with the college indulges in any malpractice or improper conduct mentioned in clause 6 to 8. | Student of the colleges expulsion from the examination hall and cancellation of the performance in that subject and all other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the subjects of that semester/year. The candidate is also debarred and forfeits the seat. Person(s) who do not belong to the College will be handed over to police and, a 8police case will be registered against them. |
| 10 | Comes in a drunken condition to the examination hall. | Expulsion from the examination hall and cancellation of the performance in that subject and all other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the subjects of that semester/year. |
| 11 | Copying detected on the basis of internal evidence, such as, during valuation or during special scrutiny. | Cancellation of the performance in that subject and all other subjects the candidate has appeared including practical examinations and project work of that semester / year examinations. |
| 12 | If any malpractice is detected which is not covered in the above clauses 1 to 11 shall be reported to the College / University for further action to award suitable punishment. | |

## 19. GENERAL:

- **Credit**: A unit by which the course work is measured. It determines the number of hours of instructions required per week. One credit is equivalent to one hour of teaching (lecture or tutorial) or two hours of practical work/field work per week.
- **Credit Point:** It is the product of grade point and number of credits for a course.
- The Academic Regulations should be read as a whole for the purpose of any interpretation.
- The University/College reserves the right of altering the Academic Regulations and/or Syllabus/Course Structure, as and when necessary. The modifications or amendments may be applicable to all the candidates on rolls, as specified by the University/College.
- Wherever the words 'he' or 'him' or 'his' occur in the above regulations, they will also include 'she' or 'her' or 'hers'.
- Wherever the word 'Subject' occurs in the above regulations, it implies the 'Theory Subject', 'Practical Subject' or 'Lab.' and 'Seminar'.
- In case of any ambiguity or doubt in the interpretations of the above regulations, the decision of the Vice-Chancellor will be final.

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## JNTUH COLLEGE OF ENGINEERING HYDERABAD

## M.Tech. (Power Electronics & Industrial Drives) – Part Time w.e.f. 2016-17

**I SEMESTER**

| S.No. | Subject | L | T | P | Credits |
|---|---|---|---|---|---|
| 1 | Power Electronic Converters | 4 | 0 | 0 | 4 |
| 2 | Elective-I | 4 | 0 | 0 | 4 |
| 3 | Elective-II | 4 | 0 | 0 | 4 |
| 4 | Power Converters Simulation Lab | 0 | 0 | 4 | 2 |
| | **Total Credits** | | | | **14** |

**II SEMESTER**

| S.No. | Subject | L | T | P | Credits |
|---|---|---|---|---|---|
| 1 | Power Electronic Control of DC Drives | 4 | 0 | 0 | 4 |
| 2 | Elective – III | 4 | 0 | 0 | 4 |
| 3 | Elective – IV | 4 | 0 | 0 | 4 |
| 4 | General Seminar | 0 | 0 | 4 | 2 |
| | **Total Credits** | | | | **14** |

**III SEMESTER**

| S.No. | Subject | L | T | P | Credits |
|---|---|---|---|---|---|
| 1 | Advanced Power Electronic Converters | 4 | 0 | 0 | 4 |
| 2 | Elective – V | 4 | 0 | 0 | 4 |
| 3 | Elective –VI | 4 | 0 | 0 | 4 |
| 4 | Power Converters Lab | 0 | 0 | 4 | 2 |
| | **Total Credits** | | | | **14** |

**IV SEMESTER**

| S.No. | Subject | L | T | P | Credits |
|---|---|---|---|---|---|
| 1 | Power Electronic Control of AC Drives | 4 | 0 | 0 | 4 |
| 2 | Elective – VII | 4 | 0 | 0 | 4 |
| 3 | Elective – VIII | 4 | 0 | 0 | 4 |
| 4 | Technical Seminar | 0 | 0 | 4 | 2 |
| | **Total Credits** | | | | **14** |

**V SEMESTER**

| S.No. | Subject | L | T | P | Credits |
|---|---|---|---|---|---|
| 1 | Comprehensive Viva voce | - | - | - | 4 |
| 2 | Project Phase- I | - | - | - | 12 |
| | **Total Credits** | | | | **16** |

**VI SEMESTER**

| S.No. | Subject | L | T | P | Credits |
|---|---|---|---|---|---|
| 1 | Project Phase - II & Dissertation | - | - | - | 18 |
| | **Total Credits** | | | | **18** |

**Elective -1**

1. Machine Modeling and Analysis
2. Reactive Power Compensation and Management
3. High Frequency Magnetic Components

**Elective -2**

1. Analysis of HVDC Systems
2. Renewable Energy Systems
3. Electric Traction Technologies

**Elective -3**

1. Modern Control Theory
2. Advanced Digital Signal Processing
3. Industrial Instrumentation

**Elective -4**

1. Microcontrollers and Applications
2. Embedded Systems
3. Reliability Engineering
4. Optimization Techniques
5. Energy Generation from Waste
6. Integration of Energy Sources

**Elective-5**

1. Dynamics of Electrical Machines
2. Special Machines
3. Smart Grid Technologies

**Elective-6**

1. Flexible AC Transmission Systems
2. Switched Mode Power Supplies
3. Digital Control Systems

**Elective-7**

1. Power Quality
2. Solar Photo Voltaic Systems
3. Hybrid Electric Vehicles

**Elective-8**

1. Programmable Logic Controllers and Applications
2. AI Techniques in Electrical Engineering
3. Energy Efficient Systems
4. Software Engineering
5. Energy Storage Technologies
6. Electrical Engineering Materials

## JNTUH COLLEGE OF ENGINEERING HYDERABAD

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### POWER ELECTRONIC CONVERTERS
### (Core Theory – 1)

**Prerequisite: Power Electronics**

**Course Objectives:**

- To understand the characteristics and principle of operation of modern power semi conductor devices.
- To comprehend the concepts of different power converters and their applications
- To analyze and design switched mode regulators for various industrial applications.

**Course Outcomes:** At the end of the course, the student is able to:

- Choose appropriate device for a particular converter topology.
- Use power electronic simulation packages for analyzing and designing power converters.

**UNIT I: AC VOLTAGE CONTROLLERS**

Single phase AC voltage controllers with Resistive, Resistive-inductive and Resistive-inductive-induced e.m.f. loads – ac voltage controllers with PWM Control – Effects of source and load inductances - Synchronous tap changers.

Three phase AC voltage controllers – Analysis of controllers with star and delta Connected Resistive, Resistive-inductive loads – Effects of source and load Inductances – Applications & Problems.

**UNIT II: CYCLO-CONVERTERS**

Single phase to single phase cyclo-converters – analysis of midpoint and bridge Configurations – Three phase to three phase cyclo-converters –analysis of Midpoint and bridge configurations – Limitations – Advantages – Applications & Problems - Matrix Converter.

**UNIT III: SINGLE PHASE & THREE PHASE CONVERTERS**

Single phase converters – Half controlled and Fully controlled converters – Evaluation of input power factor and harmonic factor – continuous and Discontinuous load current – single phase dual converters – power factor Improvements Techniques– Extinction angle control – symmetrical angle control, PWM – single phase sinusoidal PWM – single phase series converters – overlap analysis – Applications & Problems.

Three phase converters – Half controlled and fully controlled converters – Evaluation of input power factor and harmonic factor – continuous and Discontinuous load current – three phase dual converters – power factor Improvements Techniques– three phase PWM - twelve pulse converters – Applications – Problems – Design of converters.

**UNIT IV: D.C. TO D.C. CONVERTERS**

Analysis of step-down and step-up dc to dc converters with Resistive and Resistive-inductive loads – Switched mode regulators – Analysis of Buck Regulators - Boost regulators – buck and boost regulators – Cuk regulators – Condition for continuous inductor current and capacitor voltage – comparison of regulators –Multi output boost converters – advantages – Applications – Problems.

**UNIT V: PULSE WIDTH MODULATED INVERTERS**

Principle of operation – performance parameters – single phase bridge inverter- evaluation of output voltage and current with resistive, inductive and Capacitive loads– Voltage control

of single phase inverters – single PWM – Multiple PWM – sinusoidal PWM – modified PWM – phase displacement Control – Advanced modulation techniques for improved performance – Trapezoidal, staircase, stepped, harmonic injection and delta modulation – Advantages – Applications & Problems.

Three phase inverters – analysis of 180 degree conduction for output voltage And current with resistive, inductive loads – analysis of 120 degree Conduction – voltage control of three phase inverters – sinusoidal PWM – Third Harmonic PWM – 60 degree PWM – space vector modulation – Comparison of PWM techniques – harmonic reductions – Problems.

**TEXT BOOKS:**

1. Mohammed H. Rashid “Power Electronics” Pearson Education Third Edition – First Indian reprint 2004.
2. Ned Mohan, Tore M. Undeland and William P. Robbins, “Power Electronics” - John Wiley & Sons – Second Edition.

**REFERENCES:**

1. Milliman Shepherd and Lizang – “Power converters circuits” – Chapter 14 (Matrix converter) PP- 415-444,
2. M.H.Rashid - Power electronics hand book –
3. Marian P. Kaźmierkowski, Ramu Krishnan, Frede Blabjerg Edition:” Control in power electronics” illustrated Published by Academic Press, 2002.

## JNTUH COLLEGE OF ENGINEERING HYDERABAD

**M.Tech. (PTPG) I-Sem (PE&ID)**

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## DE – 1.1: MACHINE MODELING AND ANALYSIS

**Prerequisite: Electrical Machines**

**Course Objectives:**

- Identifying the methods and assumptions in modeling of machines.
- Recognize the different frames for modeling of AC machines.
- To write voltage and torque equations in state space form for different machines.

**Course Outcomes:** At the end of the course, the student is able to:

- Develop the mathematical models of various machines like, induction motor and Synchronous machines using modeling equations.
- Analyze the developed models in various reference frames.

**UNIT-I:**
Basic Two-pole DC machine - primitive 2-axis machine – Voltage and Current relationship – Torque equation.
Mathematical model of separately excited DC motor and DC Series motor in state variable form – Transfer function of the motor - Numerical problems.
Mathematical model of D.C. shunt motor D.C. Compound motor in state variable form – Transfer function of the motor - Numerical Problems

**UNIT-II:**
Linear transformation – Phase transformation (a, b, c to α, β, o) – Active transformation (α .β, o to d, q).
Circuit model of a 3 phase Induction motor – Linear transformation - Phase Transformation – Transformation to a Reference frame – Two axis models for induction motor - dq model based DOL starting of Induction Motors

**UNIT-III:**
Voltage and current Equations in stator reference frame – equation in Rotor reference frame – equations in a synchronously rotating frame – Torque equation - Equations in state – space form.

**UNIT-IV:**
Circuits model of a 3ph Synchronous motor – Two axis representation of Synchronous Motor.
Voltage and current Equations in state – space variable form – Torque equation - dq model based short circuit fault analysis- emphasis on voltage, frequency and recovery time.

**UNIT-V:**
Modeling of Permanent Magnet Synchronous motor – Modeling of Brushless DC Motor.

**TEXT BOOKS:**

1. Generalized Machine theory - P.S. Bimbhra, Khanna Publishers
2. Analysis of electric machinery and Drives systems - Paul C. Krause, Oleg wasynezuk, Scott D. Sudhoff.
3. Thyristor control of Electric Drives - Vedam Subranmanyam.
4. Power System Stability and Control – Prabha Kundur, EPRI.

**REFERECES:**

1. Performance optimization of induction motors during Voltage-controlled soft starting, Article in IEEE Transactions On Energy Conversion, July 2004.
2. A Novel Method for Starting of Induction Motor with Improved Transient Torque Pulsations, Nithin K.S, Dr. Bos Mathew Jos, Muhammed Rafeek, Dr. Babu Paul. International Journal of Engineering and Innovative Technology (IJEIT) Volume 2, Issue 8, February 2013.

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## DE – 1.2: REACTIVE POWER COMPENSATION AND MANAGEMENT

**Prerequisite: Power Systems**

**Course Objectives:**

- To identify the necessity of reactive power compensation
- To describe load compensation
- To select various types of reactive power compensation in transmission systems
- To illustrate reactive power coordination system
- To characterize distribution side and utility side reactive power management.

**Course Outcomes:** Upon the completion of this course, the student will be able to

- Distinguish the importance of load compensation in symmetrical as well as un symmetrical loads
- Observe various compensation methods in transmission lines
- Construct model for reactive power coordination
- Distinguish demand side reactive power management & user side reactive power management

**UNIT-I: LOAD COMPENSATION**

Objectives and specifications – reactive power characteristics – inductive and capacitive approximate biasing – Load compensator as a voltage regulator – phase balancing and power factor correction of unsymmetrical loads- examples.

**UNIT-II: STEADY–STATE REACTIVE POWER COMPENSATION IN TRANSMISSION SYSTEM**

Uncompensated line – types of compensation – Passive shunt and series and dynamic shunt compensation – examples

**Transient state reactive power compensation in transmission systems:**

Characteristic time periods – passive shunt compensation – static compensations - series capacitor compensation – compensation using synchronous condensers – examples

**UNIT-III: REACTIVE POWER COORDINATION**

Objective – Mathematical modeling – Operation planning – transmission benefits – Basic concepts of quality of power supply – disturbances- steady –state variations – effects of under voltages – frequency –Harmonics, radio frequency and electromagnetic interferences

**UNIT-IV: DEMAND SIDE MANAGEMENT**

Load patterns – basic methods load shaping – power tariffs- KVAR based tariffs penalties for voltage flickers and Harmonic voltage levels

**Distribution side Reactive power Management**:

System losses –loss reduction methods – examples – Reactive power planning – objectives – Economics Planning capacitor placement – retrofitting of capacitor banks

**UNIT-V: USER SIDE REACTIVE POWER MANAGEMENT**

KVAR requirements for domestic appliances – Purpose of using capacitors – selection of capacitors – deciding factors – types of available capacitor, characteristics and Limitations

**Reactive power management in electric traction systems and are furnaces:**
Typical layout of traction systems – reactive power control requirements – distribution transformers- Electric arc furnaces – basic operations- furnaces transformer –filter requirements – remedial measures –power factor of an arc furnace

**TEXT BOOKS:**
1. Reactive power control in Electric power systems by T.J.E.Miller, John Wiley and sons, 1982.
2. Reactive power Management by D.M.Tagare, Tata McGraw Hill, 2004.

**REFERENCES:**
1. Wolfgang Hofmann, Jurgen Schlabbach, Wolfgang Just “Reactive Power Compensation: A Practical Guide, April, 2012, Wiely publication.

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### DE – 1.3: HIGH FREQUENCY MAGNETIC COMPONENTS

**Prerequisite: Power Systems**

**Course Objectives:**

- To have a knowledge on magnetic circuits
- To know the skin effect and proximity effect
- To analyze the basics of transformer design for different topologies

**Course Outcomes:** Upon the completion of this course, the student will be able to

- Design of magnetic components (i.e., inductor and transformer) in a converter.
- Perform steady-state analysis of switched mode power supply.
- Understand core loss in an electromagnetic device, recognize & describe its effect.
- Describe the engineering uses of electromagnetic waves, by frequency band, and the respective hazards associated with them

**UNIT-I:**

**Fundamentals of Magnetic Devices:** Introduction, Magnetic Relationships, Magnetic Circuits, Magnetic Laws, Eddy Currents, Core Saturation, Volt-Second Balance, Inductance, Inductance Factor, Magnetic Energy, Self-Resonant Frequency, Classification of Power Losses in Magnetic Components, Non-inductive Coils.

**Magnetic Cores:** Introduction, Properties of Core Materials, Magnetic Dipoles, Magnetic Domains, Curie Temperature, Magnetization, Magnetic Materials, Hysteresis, Core Permeability, Core Geometries, Iron Alloy Cores, Amorphous Alloy Cores, Nickel–Iron and Cobalt–Iron Cores, Ferrite Cores, Powder Cores, Nano-crystalline Cores, Superconductors, Hysteresis Core Loss, Eddy-Current Core Loss, Total Core Loss, Complex Permeability.

**UNIT-II:**

**Skin Effect & Proximity Effect:** Introduction, Magnet Wire, Wire Insulation, Skin Depth, Ratio of AC-to-DC Winding Resistance, Skin Effect in Long Single Round Conductor, Current Density in Single Round Conductor, Impedance of Round Conductor, Magnetic Field Intensity for Round Wire, Other Methods of Determining the Round Wire Inductance, Power Density in Round Conductor, Skin Effect on Single Rectangular Plate. Proximity and Skin Effects in Two Parallel Plates, Anti-proximity and Skin Effects in Two Parallel Plates, Proximity Effect in Multiple-Layer Inductor, Appendix: Derivation of Proximity Power Loss.

**Winding Resistance at High Frequencies:** Introduction, Winding Resistance, Square and Round Conductors, Winding Resistance of Rectangular Conductor, Winding Resistance of Square Wire, Winding Resistance of Round Wire, Leakage Inductance, Solution for Round Conductor Winding in Cylindrical Coordinates, Litz Wire, Winding Power Loss for Inductor Current with Harmonics, Effective Winding Resistance for Non-sinusoidal Inductor Current, Thermal Model of Inductors.

**UNIT-III:**

**Transformers:** Introduction, Neumann's Formula for Mutual Inductance, Mutual Inductance, Energy Stored in Coupled Inductors, Magnetizing Inductance, Leakage Inductance, Measurement of Transformer Inductances, Stray Capacitance, High-Frequency Transformer Model, Non-interleaved Windings, Interleaved Windings, AC Current Transformers, Winding Power Losses with Harmonics, Thermal Model of Transformers.

**Design of Transformers:** Introduction, Area Product Method, Optimum Flux Density, Transformer Design for Fly-back Converter in CCM, Transformer Design for Fly-back Converter in DCM, Transformer Design for Fly-back Converter in CCM, Transformer Design for Fly-back Converter in DCM.

**UNIT-IV:**

**Integrated Inductors:** Introduction, Resistance of Rectangular Trace, Inductance of Straight Rectangular Trace, Construction of Integrated Inductors, Meander Inductors, Inductance of Straight Round Conductor, Inductance of Circular Round Wire Loop, Inductance of Two-Parallel Wire Loop, Inductance of Rectangle of Round Wire, Inductance of Polygon Round Wire Loop, Bond-wire Inductors, Single-Turn Planar Inductor, Inductance of Planar Square Loop, Planar Spiral Inductors, Multi-metal Spiral Inductors, Planar Transformers, MEMS Inductors, Inductance of Coaxial Cable, Inductance of Two-Wire Transmission Line, Eddy Currents in Integrated Inductors, Model of RF Integrated Inductors, PCB Inductors.

**Design of Inductors:** Introduction, Restrictions on Inductors, Window Utilization Factor, Temperature Rise of Inductors, Mean Turn Length of Inductors, Area Product Method, AC Inductor Design, Inductor Design for Buck Converter in CCM, Inductor Design for Buck Converter in DCM method.

**UNIT-V:**

**Self-Capacitance:** Introduction, High-Frequency Inductor Model, Self-Capacitance Components, Capacitance of Parallel-Plate Capacitor, Self-Capacitance of Foil Winding Inductors, Capacitance of Two Parallel Round Conductors, Capacitance of Round Conductor and Conducting Plane, Self-Capacitance of Single-Layer Inductors, Self-Capacitance of Multi-layer Inductors, Capacitance of Coaxial Cable.

**TEXT BOOKS:**

1. Design of Magnetic Components for Switched Mode Power Converters, Umanand L., Bhat,S.R., ISBN:978-81-224-0339-8, Wiley Eastern Publication, 1992.

**REFERENCES:**

1. High-Frequency Magnetic Components, Marian K. Kazimierczuk, ISBN: 978-0-470-71453-9 John Wiley & Sons, Inc.
2. G.C. Chryssis, High frequency switching power supplies, McGraw Hill, 1989 (2nd Edn.)
3. Eric Lowdon, Practical Transformer Design Handbook, Howard W. Sams & Co., Inc., 1980
4. “Thompson --- Electrodynamic Magnetic Suspension.pdf”
5. Witulski --- “Introduction to modeling of transformers and coupled inductors” Beattie --- “Inductance 101.pdf”
6. P. L. Dowell, "Effects of eddy currents in transformer windings.pdf"
7. Dixon--- “Eddy current losses in transformer windings.pdf”
8. J J Ding, J S Buckkeridge, “Design Considerations For A Sustainable Hybrid Energy System” IPENZ Transactions, 2000, Vol. 27, No. 1/EMCh.
9. Texas Instruments --- “Windings.pdf”
10. Texas Instruments --- “Magnetic core characteristics.pdf” Ferroxcube --- “3f3 ferrite datasheet.pdf” Ferroxcube --- “Ferrite selection guide.pdf” Magnetics, Inc., Ferrite Cores (www.mag-inc.com).

## JNTUH COLLEGE OF ENGINEERING HYDERABAD

**M.Tech. (PTPG) I-Sem (PE&ID)**

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## DE – 2.1: ANALYSIS OF HVDC SYSTEMS

**Prerequisite: Power Electronics and Power Systems**

**Course Objectives:**

- To Comprehend the conversion principles of HVDC Transmission
- Analysis of 3, 6, 12 pulse converters, rectifier and inverter operations of HVDC converters
- To identify the different types of Harmonics and its suppression methods including Filters
- To comprehend the requirement of grounding and grounding electrodes for HVDC systems.

**Course Outcomes:** Upon the completion of this course, the student will be able to

- Find the applications of HVDC transmission in the power system with the acquired knowledge.
- Analyze different converter topologies viz. 3, 6 and 12 Pulse converters and understand it's control aspects.
- Understand the filter configuration and harmonic suppression methods.
- Have knowledge on grounding electrodes and their design for HVDC systems.

**UNIT-I**

**INTRODUCTION:** General consideration, Power Handling Capabilities of HVDC Lines Basic Conversion principles, static converter configuration.

**STATIC POWER CONVERTERS:** 3-pulse, 6-pulse, and 12-pulse converters, converter station and Terminal equipment, commutation process, Rectifier and inverter operation, equivalent circuit for converter – special features of converter transformers

**UNIT-II**

**CONTROL OF HVDC CONVERTERS AND SYSTEMS:** Introduction – Mechanism of AC power transmission – principles of control – necessity of control in case of a DC link – Rectifier control – compounding of rectifiers – power reversal in a DC link – VDCOL Characteristics of converter – System control hierarchy – Inverter extinction angle control – pulse phase control – starting and stopping of a DC link – constant power control – control systems for HVDC converters inverter operation problems control of VSC converters.

**UNIT-III**

**HARMONICS IN HVDC SYSTEMS:** Introduction – Generation of harmonics by converters – Characteristic harmonics on DC side – Characteristic Current harmonics – Characteristic variation of Harmonic currents – Effect of control modes on harmonics – Non-characteristic harmonics – Harmonics in VSC converters.

**UNIT-IV**

**HARMONIC SUPPRESSION IN HVDC SYSTEMS – FILTERS:** Introduction – Harmonic model and Equivalent circuit – use of filters – filter configuration – design of band-pass filter – minimum cost of tuned AC filters – design of high-pass filters – protection of filters – Reactive power considerations – DC filters – Power line communication and RI noise – Active filters and their applications – Filters with VSC HVDC schemes – other methods of harmonic elimination.

**UNIT-V**

**GROUNDING AND GROUNDING ELECTRODES FOR HVDC SYSTEMS:** Introduction – Advantages and problems with ground return – HVDC systems grounding – The current field in earth near an electrode – Resistance of electrodes-electric current field – Distribution of current field between the electrodes – natural current field due to the Earth's magnetic field – Effect of ground return on buried objects – requirements of electrodes – basic parameters of design of ground electrodes – design of land electrodes.

**TEXT BOOKS:**

1. E.W. Kimbark: Direct current Transmission, Wiely Inter Science – New York.
2. HVDC Transmission by S. Kamakshaiah, V. Kamaraju, Tata McGraw Hill Education Private Limited.
3. J. Arillaga HVDC Transmission Peter Peregrinus ltd. London UK 1983.

**REFERENCES:**

1. K. R. Padiyar, "High Voltage Direct current Transmission", Wiely Eastern Ltd New Delhi – 1992.
2. E. Uhlman, "Power Transmission by Direct Current", Springer Verlag, Berlin Helberg. 1985.

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## DE – 2.2: RENEWABLE ENERGY SYSTEMS

**Prerequisite: None**

**Course Objectives:**

- To recognize the awareness of energy conservation in students
- To identify the use of renewable energy sources for electrical power generation
- To collect different energy storage methods
- To detect about environmental effects of energy conversion

**Course Outcomes:** Upon the completion of this course, the student will be able to

- find different renewable energy sources to produce electrical power
- estimate the use of conventional energy sources to produce electrical energy
- role-play the fact that the conventional energy resources are depleted
- arrange Store energy and to avoid the environmental pollution

**UNIT-I**

Photo voltaic power generation ,spectral distribution of energy in solar radiation, solar cell configurations, voltage developed by solar cell, photo current and load current, practical solar cell performance, commercial photo voltaic systems, test specifications for PV systems, applications of super conducting materials in electrical equipment systems.

**UNIT-II**

Principles of MHD power generation, ideal MHD generator performance, practical MHD generator, MHD technology.

**Wind Energy conversion:** Power from wind, properties of air and wind, types of wind Turbines, operating characteristics.

**UNIT-III**

Tides and tidal power stations, modes of operation, tidal project examples, turbines and generators for tidal power generation.

**Wave energy conversion:** properties of waves and power content, vertex motion of Waves, device applications. Types of ocean thermal energy conversion systems Application of OTEC systems examples,

**UNIT-IV**

**Miscellaneous energy conversion systems:** coal gasification and liquefaction, biomass conversion, geothermal energy, thermo electric energy conversion, principles of EMF generation, description of fuel cells, Co-generation and energy storage, combined cycle co-generation, energy storage.

**Global energy position and environmental effects:** energy units, global energy position.

**UNIT-V**

Types of fuel cells, $H_2$-$O_2$ Fuel cells, Application of fuel cells – Batteries, Description of batteries, Battery application for large power. Environmental effects of energy conversion systems, pollution from coal and preventive measures steam stations and pollution, pollution free energy systems.

**TEXT BOOKS:**

1. "Energy conversion systems" by Rakosh das Begamudre, New age International publishers, New Delhi
 - 2000.
2. "Renewable Energy Resources" by John Twidell and Tony Weir, 2nd Edition, Fspon & Co.

**REFERENCES:**

1. "Understanding Renewable Energy Systems", by Volker Quaschning, 2005, UK.
2. "Renewable Energy Systems-Advanced Conversion, Technologies & Applications" by Faner Lin Luo Honer Ye, CRC press, Taylor & Francis group.

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## DE – 2.3: ELECTRICAL TRACTION TECHNOLOGIES

**Course Objectives:**

- To be able to understand various systems of track electrification, power supply system and mechanics of electric train.
- To understand various motors used in the electric traction and their converters.

**UNIT – I**

**Traction Systems :** Electric drives - Advantages & disadvantages - System of track electrification - DC, 1-Phase low frequency, 3-Phase low frequency and composite systems, Problems of 1-phase traction system - Current unbalance, Voltage unbalance, Production of harmonics, Induction effects, Booster transformer - Rail connected booster transformer. Comparison between ac and dc systems.

**UNIT – II**

**Traction mechanics:** Types of services, Speed - time curves - Construction of quadrilateral and trapezoidal speed time curves, Average & schedule speeds. Tractive effort - Speed characteristic, Power of traction motor, specific energy consumption - Factors affecting specific energy consumption, Coefficient of adhesion, slip - Factors affecting slip, magnetically suspended trains.

**UNIT – III**

**Power supply arrangements :** High voltage supply, Constituents of supply system - Substations, Feeding post, Feeding & sectioning arrangements, Remote control center, Design considerations of substations, Over head equipment - principle of design of OHE, Polygonal OHE - Different types of constructions, Basic sag & tension calculations, Dropper design, Current collection gear for OHE.

**UN IT – IV**

**Traction motors :** Desirable characteristics, D.C. series motors, A.C. series motors, 3-Phase induction motors, linear induction motors, D.C. motor series & parallel control - Shunt bridge transition – Drum controller, Contact type bridge transition control, Energy saving, Types of braking in a.c. and d.c. drives, Conditions for regenerative braking, Stability of motors under regenerative braking.

**UNIT – V**

**Semi conductor converter controlled drives:** Advantages of 25KV of AC Traction - Control of d.c. motors - single and two stage converters, Control of ac. motors - CSI fed squirrel cage induction motor, PWM VSI induction motor drive, D.C. traction — Chopper controlled d.c. motors, composite braking, Diesel electric traction — D.C. generator fed d.c. series motor, Alternator fed d.c. series motor, Alternator fed squirrel cage induction motor, Locomotive and axle codes. Introduction to new technologies in superspeed electric locomotives.

**TEXT BOOKS :**

1. Partab.H - Modern Electric Traction, Dhanpat Rai & Sons – 1998.
2. Dubey. G.K. - Fundamentals of Electrical Drives, Narosa Publishing House - 2001.
3. C.LWadhwa - Generation, Distribution and Utilization of Electrical Energy, New Age International - 2006.
4. J.B. Gupta - Utilization of Electrical Power and Electric Traction, S.K. Kataria & Sons publications, 9th edition 2004.

**REFERENCES:**

1. www.siemens.com/mobility/locomotives
2. www.abb.com/railway

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## POWER CONVERTERS SIMULATION LAB

1. Single phase full converter using RL and E loads.
2. Single phase semi converter using RL and E loads.
3. Three phase full converter using RL and E loads.
4. Three phase semi converter using RL and E loads.
5. Single phase AC Voltage controller using RL load.
6. Single phase Cyclo-converter Voltage controller using RL load.
7. Three-phase inverter with PWM controller.
8. DC-DC Converters.
9. Modeling of Separately Excited DC Motor.
10. Modeling of Three Phase Induction Motor.

**Note:** Use any two suitable software's for each simulation.

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## POWER ELECTRONIC CONTROL OF DC DRIVES
## (Core Theory – 2)

**Prerequisite: Power Electronics**

**Course Objectives:**

- To introduce drive system, characteristics of drive, and operating modes of drive
- To comprehend the principle and operation of phase control & Chopper controlled of dc drives.
- To design a current and speed controllers to achieve closed loop operation of dc drives.

**Course Outcomes:** After completing this course, student will be able to:

- Perform simulations of phase and chopper controlled dc drive both for open loop and closed loop operations.
- Choose proper gain values for speed and current controllers.
- Distinguish the difference between PWM controller and hysteresis controller.

### UNIT–I: SINGLE-PHASE RECTIFIER CONTROLLED DC MOTOR

Separately excited DC motors and DC series motors with rectified single phase supply – single phase semi converter and single phase full converter for continuous and discontinuous modes of operation – power and power factor.

### UNIT–II: THREE-PHASE RECTIFIERS CONTROLLED DC MOTOR (SEPARATELY EXCITED & SERIES)

Three-phase controlled converter, control circuit, control modeling of three phase converter – Steady state analysis of three phase converter control DC motor drive – Two quadrant, Three phase converter controlled DC motor drive – DC motor and load, converter.

### UNIT–III: CLOSED LOOP CONTROL OF DC DRIVE

Current and speed controllers - Current and speed feedback – Design of controllers – Current and speed controllers – Motor equations – filter in the speed feedback loop speed controller – current reference generator – current controller and flow chart for simulation – Harmonics and associated problems – sixth harmonics torque.

### UNIT–IV: CHOPPER CONTROLLED DC MOTOR DRIVES

Principle of operation of the chopper – Chopper with other power devices – model of the chopper – input to the chopper – steady state analysis of chopper controlled DC motor drives – rating of the devices – Pulsating torque.

**Closed loop operation:** Speed controlled drive system – current control loop – pulse width modulated current controller – hysteresis current controller – modeling of current controller – design of current controller.

### UNIT–V: FOUR QUADRANT OPERATION OF DC DRIVES

Introduction to Four quadrant operation – Motoring operations, Electric Braking – Plugging, Dynamic and Regenerative Braking operations. Four quadrant operation of D.C motors by single phase, three phase dual converters and Choppers – Closed loop operation of DC motor.

**TEXT BOOKS:**

1. Power Electronics and motor control – Shepherd, Hulley, Liang – II Edition Cambridge University Press.
2. Electronic motor drives modeling Analysis and control – R. Krishnan – I Edition Prentice Hall India.
3. Power Electronics circuits, Devices and Applications – MH Rashid – PHI – 1 Edition 1995.
4. Power Semiconductor Drives – G. K. Dubey, Narosa Publishers –

**REFERENCES:**

1. Fundamentals of Electric Drives – GK Dubey, Narosa Publishers 1995
2. Power Semiconductor drives – SB Dewan and A Straughen -1975.

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## DE – 3.1: MODERN CONTROL THEORY

**Prerequisite: Control Systems**

**Course Objectives:**

- To explain the concepts of basics and modern control system for the real time analysis and design of control systems.
- To explain the concepts of state variables analysis.
- To study and analyze non linear systems.
- To analyze the concept of stability for nonlinear systems and their categorization.
- To apply the comprehensive knowledge of optimal theory for Control Systems.

**Course Outcomes:** Upon completion of this course, students should be able to:

- Various terms of basic and modern control system for the real time analysis and design of control systems.
- To perform state variables analysis for any real time system.
- Apply the concept of optimal control to any system.
- Able to examine a system for its stability, controllability and observability.
- Implement basic principles and techniques in designing linear control systems.
- Formulate and solve deterministic optimal control problems in terms of performance indices.
- Apply knowledge of control theory for practical implementations in engineering and network analysis.

**UNIT-I**

**Mathematical Preliminaries and State Variable Analysis:** Fields, Vectors and Vector Spaces – Linear combinations and Bases – Linear Transformations and Matrices – Scalar Product and Norms – Eigen values, Eigen Vectors and a Canonical form representation of Linear systems – The concept of state – State space model of Dynamic systems – Time invariance and Linearity – Non uniqueness of state model – State diagrams for Continuous-Time State models - Existence and Uniqueness of Solutions to Continuous-Time State Equations – Solutions of Linear Time Invariant Continuous-Time State Equations – State transition matrix and it's properties. Complete solution of state space model due to zero input and due to zero state.

**UNIT II**

**Controllability and Observability:** General concept of controllability – Controllability tests, different state transformations such as diagonalization, Jordon canonical forms and Controllability canonical forms for Continuous-Time Invariant Systems – General concept of Observability – Observability tests for Continuous-Time Invariant Systems – Observability of different State transformation forms.

**UNIT III**

**State Feedback Controllers and Observers:** State feedback controller design through Pole Assignment, using Ackkermans formula– State observers: Full order and Reduced order observers.

**UNIT IV**

**Non-Linear Systems:** Introduction – Non Linear Systems - Types of Non-Linearities – Saturation – Dead-Zone - Backlash – Jump Phenomenon etc; Linearization of nonlinear systems, Singular Points and its types– Describing function–describing function of different types of nonlinear elements, – Stability analysis of Non-Linear systems through describing functions. Introduction to phase-plane analysis, Method of Isoclines for Constructing Trajectories, Stability analysis of nonlinear systems based on phase-plane method.

**UNIT V**

**Stability Analysis:** Stability in the sense of Lyapunov, Lyapunov's stability and Lypanov's instability theorems - Stability Analysis of the Linear continuous time invariant systems by Lyapunov second method – Generation of Lyapunov functions – Variable gradient method – Krasooviski's method.

**TEXT BOOKS:**

1. M.Gopal, Modern Control System Theory, New Age International - 1984
2. Ogata. K, Modern Control Engineering, Prentice Hall - 1997
3. N K Sinha, Control Systems, New Age International – 3rd edition.

**REFERENCES:**

1. Donald E.Kirk, Optimal Control Theory an Introduction, Prentice - Hall Network series - First edition.

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## DE – 3.2: ADVANCED DIGITAL SIGNAL PROCESSING

**Prerequisite: Digital signal processing**

**Objectives:**

- To emphasize the advanced concepts of digital signal processing and the mathematical basis of discrete time signal analysis.
- To introduce the implementation of DSP algorithms and power spectrum analysis.

**Outcomes:** After completion of this course, the students will be able to

- Solve the various types of practical problems of DSP processors.
- Develop DSP based real time systems.
- Design and analyze various filters.

**UNIT–I**

**DIGITAL FILTER STRUCTURES:** Block diagram representation – Equivalent Structures – FIR and IIR digital filter Structures AII pass Filters - tunable IIR Digital Sine-cosine generator - Computational complexity of digital filter structures.

**UNIT-II**

**DIGITAL FILTER DESIGN:** Preliminary considerations- Bilinear transformation method of IIR filter design –design of Low pass high pass – Band pass, and Band stop- IIR digital filters – Spectral transformations of IIR filters – FIR filter design – based on Windowed Fourier series – design of FIR digital filters with least – mean square-error – constrained Least – square design of FIR digital filters.

**UNIT-III**

**DSP ALGORITHM IMPLEMENTATION:** Computation of the discrete Fourier transform- Number representation – Arithmetic operations – handling of overflow – Tunable digital filters – function approximation.

**UNIT-IV**

**ANALYSIS OF FINITE WORD LENGTH EFFECTS:** The Quantization process and errors- Quantization of fixed –point and floating –point Numbers – Analysis of coefficient Quantization effects – Analysis of Arithmetic Round-off errors- Dynamic range scaling – signal –to- noise in Low –order IIR filters- Low – Sensitivity Digital filter – Reduction of Product round-off errors feedback – Limit cycles in IIR digital filter – Round – off errors in FFT Algorithms.

**UNIT-V**

**POWER SPECTRUM ESTIMATION:** Estimation of spectra from Finite Duration Observations signals- Non-parametric methods for power spectrum Estimation- parametric method for power spectrum Estimation- Estimation of spectral form-Finite duration observation of signals- Non-parametric methods for power spectrum estimation – Walsh methods – Blackman and torchy method.

**TEXT BOOKS:**

1. Sanjit K. Mitra, Digital signal processing – TMH second edition
2. Alan V. Oppenheim, Ronald W, Shafer, Discrete Time Signal Processing – PHI 1996 1st Edition reprint
3. John G. Proakis, Digital Signal Processing principles – Algorithms and Applications – PHI – 3rd edition 2002.

**REFERENCE BOOKS:**

3. S Salivahanan. A. Vallavaraj C. Gnanapriya, Digital Signal Processing – TMH – 2nd reprint 2001.
4. Lourens R Rebinarand Bernold, Theory and Applications of Digital Signal Processing.
5. Auntoniam, Digital Filter Analysis and Design, TMH.

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## DE – 3.3: INDUSTRIAL INSTRUMENTATION

**Prerequisite: None**

**Objectives:**

- To study the characteristics of instruments
- Analyze the various type s of transducers
- Principle of operation and selection of transducers depend s on their applications.
- Basic knowledge of displacement, strain, pressure, temperature, flow, level, density, and viscosity measurements.

**Outcomes:** After completion of this course, the students will be able to

- Select the transducers and their types, usage and operation and different characteristics of transducers.
- Calibrate the various instruments and application of various instruments to different fields.
- Implement process techniques, instrumental setups as well as controlling and monitoring of various processes in the industries.

**UNIT – I: INTRODUCTION:**
Introduction to Instrumentation system - Static and Dynamic characteristics of Instruments - Principles of transducers.

**UNIT- II: MEASUREMENT OF DISPLACEMENT & STRAIN:**
Displacement and proximity gauges - Linear Variable Differential Transformer (LVDT) - Measurement of strain: Strain Gauge - unbalanced Wheatstone bridge.

**UNIT – III: MEASUREMENT OF TEMPERATURE:**
Thermocouples - Resistance Temperature Detector (RTD) - Thermisters and radiation pyrometer.

**UNIT- IV : MEASUREMENT OF FLOW:**
Measurement of level: Capacitance based and Float based method.Differential pressure flow meters - variable area flow meters- variable reluctance flow meters - Turbine flow meter - Ultrasonic flow meter (Both transit time and Doppler Shift) - Electromagnetic flow meter and mass flow meter.

**UNIT – V: MEASUREMENT OF PRESSURE & OTHER QUANTITIES:**
Elastic transducers- Low pressure measurement-McLeod and ionization gauge-Load cell - Torque Cell - pH probe and viscosity measurement - Basics of Data transmission - Synchro and Servo motor - Pneumatic and Hydraulic Instrumentation system.

**TEXT BOOK:**

1. E. Doeblin," Industrial Instrumentation"- CRC Press
2. A.K.Sawhney, Course in Electrical and Electronics Measurements and Instrumentation, Dhanpat Rai & Company

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### DE – 4.1: MICROCONTROLLERS AND APPLICATIONS

**Prerequisite: Microprocessors and Interfacing Devices**

**Course Objectives:**

- To relate the basic architecture and addressing modes of a microcontroller.
- To explain the principles of top down design to microcontroller software development
- To demonstrate assembly language programs for the advanced Microcontroller , assembly language code for high-level language structures such as IF-THEN-ELSE and DO-WHILE
- To analyze a typical I/O interface and to discuss timing issues
- To identify different types of memory used in microcontrollers

**Course Outcomes:** Upon the completion of this course, the student will be able to

- Distinguish types of computers & microcontrollers,
- Know 8-Bit, 16- Bit & 32 Bit advanced Microcontrollers.
- Develop Real time Applications of Microcontrollers & Demonstrate RTOS for Microcontrollers.
- Translate Hardware applications using Microcontrollers.

**UNIT-I: OVERVIEW OF ARCHITECTURE & MICROCONTROLLER RESOURCES**

Architecture of a microcontroller – Microcontroller resources – Resources in advanced and next generation microcontrollers – 8051 microcontroller – Internal and External memories – Counters and Timers – Synchronous serial-cum asynchronous serial communication - Interrupts.

**UNIT-II: 8051- MICROCONTROLLERS INSTRUCTION SET**

Basic assembly language programming – Data transfer instructions – Data and Bit-manipulation instructions – Arithmetic instructions – Instructions for Logical operations on the test among the Registers, Internal RAM, and SFRs – Program flow control instructions – Interrupt control flow.

**UNIT-III: REAL TIME CONTROL**

**INTERRUPTS:** Interrupt handling structure of an MCU – Interrupt Latency and Interrupt deadline – Multiple sources of the interrupts – Non-maskable interrupt sources – Enabling or disabling of the sources – Polling to determine the interrupt source and assignment of the priorities among them – Interrupt structure in Intel 8051.

**TIMERS:** Programmable Timers in the MCU's – Free running counter and real time control – Interrupt interval and density constraints.

**UNIT-IV: SYSTEMS DESIGN**

**DIGITAL AND ANALOG INTERFACING METHODS:** Switch, Keypad and Keyboard interfacings – LED and Array of LEDs – Keyboard-cum-Display controller (8279) – Alphanumeric Devices – Display Systems and its interfaces – Printer interfaces – Programmable instruments interface using IEEE 488 Bus – Interfacing with the Flash Memory – Interfaces – Interfacing to High Power Devices – Analog input interfacing – Analog output interfacing – Optical motor shaft encoders – Industrial control – Industrial process control system – Prototype MCU based Measuring instruments – Robotics and Embedded control – Digital Signal Processing and digital filters.

**UNIT-V: REAL TIME OPERATING SYSTEM FOR MICROCONTROLLERS:**
Real Time operating system – RTOS of Keil (RTX51) – Use of RTOS in Design – Software development tools for Microcontrollers.

**16-BIT MICROCONTROLLERS:** Hardware – Memory map in Intel 80196 family MCU system – IO ports – Programmable Timers and High-speed outputs and input captures – Interrupts – instructions.
ARM 32 Bit MCUs: Introduction to 16/32 Bit processors – ARM architecture and organization – ARM / Thumb programming model – ARM / Thumb instruction set – Development tools.

**TEXT BOOKS:**
1. Raj Kamal, "Microcontrollers Architecture, Programming, Interfacing and System Design" – Pearson Education, 2005.
2. Mazidi and Mazidi, "The 8051 Microcontroller and Embedded Systems" – PHI, 2000.

**REFERENCES:**
1. A.V. Deshmuk, "Microcontrollers (Theory & Applications)" – WTMH, 2005.
2. John B. Peatman, "Design with PIC Microcontrollers" – Pearson Education, 2005.
3. Microcontroller Programming, Julio Sanchez, Maria P. Canton, CRC Press.
4. The 8051 Microcontroller, Ayala, Cengage Learning.
5. Microprocessors and Microcontrollers, Architecture, Programming and System Design, Krishna Kant, PHI Learning PVT. Ltd.
6. Microprocessors, Nilesh B. Bahadure, PHI Learning PVT. Ltd.

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### DE – 4.2: EMBEDDED SYSTEMS

**Prerequisite: Microprocessors and Interfacing Devices**

**Course Objectives:**

- To emphasize the general embedded system concepts, design of embedded hardware and software development tools
- To explain the basics of real time operating and embedded systems
- To describe key issues such as CPU scheduling, memory management, task synchronization, and file system in the context of real-time embedded systems.

**Course Outcomes:** Upon the completion of this course, the student will be able to

- To analyze and design embedded systems and real-time systems
- Define the unique design problems and challenges of real-time systems
- Identify the unique characteristics of real-time operating systems and evaluate the need for real-time operating system
- Explain the general structure of a real-time system and Understand and use RTOS to build an embedded real-time system
- Gain knowledge and skills necessary to design and develop embedded applications based on real-time operating systems.

**UNIT- I: OVERVIEW OF EMBEDDED SYSTEM**

Embedded System, types of Embedded System, Requirements of Embedded System, and Issues in Embedded software development, Applications.

**UNIT-II: PROCESSOR & MEMORY ORGANIZATION**

Structural units in a processor, Processor selection, Memory devices, Memory selection, Memory Allocation & Map, Interfacing.

**UNIT-III: DEVICES, DEVICE DRIVERS & BUSES FOR DEVICE NETWORKS**

I/O devices, Timer & Counter devices, Serial Communication, Communication between devices using different buses. Device drives, Parallel and serial port device drives in a system, Interrupt servicing mechanism, context and periods for context switching, Deadline and Interrupt Latency.

**UNIT-IV: PROGRAMMING & MODELING CONCEPTS**

Program elements, Modeling Processes for Software Analysis, Programming Models, Modeling of Multiprocessor Systems, Software algorithm Concepts, design, implementation, testing, validating, debugging, Management and maintenance, Necessity of RTOS.

**UNIT-V: HARDWARE AND SOFTWARE CO-DESIGN**

Embedded system design and co-design issues in software development, design cycle in development phase for Embedded System, Use of ICE & Software tools for development of ES, Issues in embedded system design.

**TEXTBOOKS:**

1. Embedded systems: Architecture, programming and design by Rajkamal, TMH
2. Embedded system design by Arnold S Burger, CMP

**REFERENCES:**

1. An embedded software primer by David Simon, PEA
2. Embedded systems design:Real world design be Steve Heath; Butterworth Heinenann, Newton mass, USA 2002
3. Data communication by Hayt.

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## DE – 4.3: RELIABILITY ENGINEERING

**Prerequisite: None**

**Course Objectives:**

- To comprehend the concept of Reliability and Unreliability
- Derive the expressions for probability of failure, Expected value and standard deviation of Binominal distribution, Poisson distribution, normal distribution and weibull distributions.
- Formulating expressions for Reliability analysis of series-parallel and Non-series parallel systems
- Deriving expressions for Time dependent and Limiting State Probabilities using Markov models.

**Learning Outcomes:** Upon the completion of this course, the student will be able to

- Apply fundamental knowledge of Reliability to modeling and analysis of series-parallel and Non-series parallel systems.
- Solve some practical problems related with Generation, Transmission and Utilization of Electrical Energy.
- Understand or become aware of various failures, causes of failures and remedies for failures in practical systems.

**Unit I:**

Rules for combining probabilities of events, Definition of Reliability. Significance of the terms appearing in the definition. Probability distributions: Random variables, probability density and distribution functions. Mathematical expectation, Binominal distribution, Poisson distribution, normal distribution, weibull distribution.

**Unit II:**

Hazard rate, derivation of the reliability function in terms of the hazard rate. Failures: Causes of failures, types of failures (early failures, chance failures and wear-out failures). Bath tub curve - Preventive and corrective maintenance - Modes of failure. Measures of reliability: mean time to failure and mean time between failures.

**Unit III:**

Classification of engineering systems: series, parallel and series-parallel systems-Expressions for the reliability of the basic configurations. Reliability evaluation of Non-series-parallel configurations: Decomposition, Path based and cutest based methods, Deduction of the Paths and cut sets from Event tree.

**Unit IV:**

Discrete Markov Chains: General modeling concepts, stochastic transitional probability matrix, time dependent probability evaluation and limiting state probability evaluation of one component repairable model. Absorbing states: Continuous Markov Processes: Modeling concepts, State space diagrams, Stochastic Transitional Probability Matrix, Evaluating time dependent and limiting state Probabilities of one component repairable model. Evaluation of limiting state probabilities of two component repairable model.

**UNIT-V:**

Approximate system Reliability analysis of Series systems, parallel systems with two and more than two components, Network reduction techniques. Minimal cutest/failure mode approach.

**TEXT BOOKS:**

1. "Reliability evaluation of Engineering systems", Roy Billinton and Ronald N Allan, BS Publications.
2. "Reliability Engineering", Elsayed A. Elsayed, Prentice Hall Publications.

**REFERENCE BOOKS:**

1. "Reliability Engineering: Theory and Practice", By Alessandro Birolini, Springer Publications.
2. "An Introduction to Reliability and Maintainability Engineering", Charles Ebeling, TMH Publications.
3. "Reliability Engineering", E. Balaguruswamy, TMH Publications.

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## DE-4.4: OPTIMIZATION TECHNIQUES

**Prerequisite: None**

**Course Objectives:**

- To understand the theory of optimization methods and algorithms developed for solving various types of optimization problems.
- To develop an interest in applying optimization techniques in problems of Engineering and Technology
- To apply the mathematical results and numerical techniques of optimization theory to concrete Engineering problems.

**Course Outcomes:** Upon the completion of this course, the student will be able to

- Know basic theoretical principles in optimization
- formulate optimization models and obtain solutions for optimization;
- apply methods of sensitivity analysis and analyze post processing of results

**UNIT – I**

**Introduction and Classical Optimization Techniques:**

Statement of an Optimization problem – design vector – design constraints – constraint surface – objective function – objective function surfaces – classification of Optimization problems.

**Classical Optimization Techniques**

Single variable Optimization – multi variable Optimization without constraints – necessary and sufficient conditions for minimum/maximum – multivariable Optimization with equality constraints.

Solution by method of Lagrange multipliers – multivariable Optimization with inequality constraints – Kuhn – Tucker conditions.

**UNIT – II**

**Linear Programming**

Standard form of a linear programming problem – geometry of linear programming problems – definitions and theorems – solution of a system of linear simultaneous equations – pivotal reduction of a general system of equations – motivation to the simplex method – simplex algorithm.

**UNIT – III**

**Transportation Problem**

Finding initial basic feasible solution by north – west corner rule, least cost method and Vogel's approximation method – testing for optimality of balanced transportation problems.

**Unconstrained Nonlinear Programming:**

One – dimensional minimization methods: Classification, Fibonacci method and Quadratic interpolation method

**UNIT – IV**

**Unconstrained Optimization Techniques**

Univariate method, Powell's method and steepest descent method.

**Constrained Nonlinear Programming:**

Characteristics of a constrained problem, Classification, Basic approach of Penalty Function method; Basic approach of Penalty Function method; Basic approaches of Interior and Exterior penalty function methods. Introduction to convex Programming Problem.

**UNIT – V**

**Dynamic Programming:**

Dynamic programming multistage decision processes – types – concept of sub optimization and the principle of optimality – computational procedure in dynamic programming – examples illustrating the calculus method of solution - examples illustrating the tabular method of solution.

**TEXT BOOKS:**

1. "Engineering optimization: Theory and practice"-by S. S.Rao, New Age International (P) Limited, 3rd edition, 1998.
2. "Introductory Operations Research" by H.S. Kasene & K.D. Kumar, Springer(India), Pvt .LTd.

**REFERENCES:**

1. "Optimization Methods in Operations Research and systems Analysis" – by K.V. Mital and C. Mohan, New Age International (P) Limited, Publishers, 3rd edition, 1996.
2. Operations Research – by Dr. S.D.Sharma.
3. "Operations Research: An Introduction" by H.A. Taha, PHI Pvt. Ltd., 6th edition
4. Linear Programming by G. Hadley

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## DE-4.5: ENERGY GENERATION FROM WASTE

**UNIT-I:**
Solid Waste Sources Solid Waste Sources, types, composition, Properties, Global warming, Municipal Solid Waste: Physical, chemical and biological properties , Waste Collection and, Transfer stations, Waste minimization and recycling of municipal waste, Segregation of waste, Size Reduction , Managing Waste. Status of technologies for generation of Energy from Waste Treatment and Disposal Aerobic composting, incineration, Furnace type and design, Medical waste /Pharmaceutical waste treatment Technologies, incineration, Environmental impacts, Measures to mitigate environmental effects due to incineration .

**UNIT-II:**
Land Fill method of Solid waste disposal Land fill classification, Types, methods and Sitting consideration, Layout and preliminary design of landfills: Composition, characteristics, generation, Movement and control of landfill leach ate and gases, Environmental monitoring system for land fill gases.

**UNIT-III:**
Energy Generation from Waste Bio-chemical Conversion: Sources of energy generation, anaerobic digestion of sewage and municipal wastes, direct combustion of MSW-refuse derived solid fuel, Industrial waste, agro residues, Anaerobic Digestion.

**UNIT-IV:**
Biogas production, Land fill gas generation and utilization, Thermo-chemical conversion: Sources of energy generation, Gasification of waste using Gasifiers, Briquetting, Utilization and advantages of briquetting, Environmental benefits of Bio-chemical and Thermo-chemical conversion.

**UNIT–V:**
E-waste: e-waste in the global context – Growth of Electrical and Electronics Industry in India – Environmental concerns and health hazards – Recycling e-waste: a thriving economy of the unorganized sector – Global trade in hazardous waste – impact of hazardous e-waste in India. Management of e-waste: e-waste legislation, Government regulations on e-waste management – International experience – need for stringent health safeguards and environmental protection laws of India.

**TEXT BOOKS:**
1. Nicholas P. Cheremisinoff. Handbook of Solid Waste Management and Waste Minimization Technologies. An Imprint of Elsevier, New Delhi (2003).
2. P. Aarne Vesilind, William A. Worrell and Debra R. Reinhart. Solid Waste Engineering. Thomson Asia Pte Ltd. Singapore (2002)
3. M. Dutta , B. P. Parida, B. K. Guha and T. R. Surkrishnan. Industrial Solid Waste Management and Landfilling practice. Narosa Publishing House, New Delhi (1999).
4. “E-waste in India: Research unit, Rajya Sabha Secretariat, New Delhi, June 2011”
5. Amalendu Bagchi. Design, construction and Monitoring of Landfills. John Wiley and Sons. New York. (1994)
6. M. L. Davis and D. A. Cornwell. Introduction to environmental engineering. Mc Graw Hill International Edition, Singapore (2008)
7. C. S. Rao. Environmental Pollution Control Engineering. Wiley Eastern Ltd. New Delhi (1995)

8. S. K. Agarwal. Industrial Environment Assessment and Strategy. APH Publishing Corporation. New Delhi (!996)
9. Sofer, Samir S. (ed.), Zaborsky, R. (ed.), “Biomass Conversion Processes for Energy and Fuels”, New York, Plenum Press, 1981
10. Hagerty, D.Joseph; Pavoni, Joseph L; Heer, John E., “Solid Waste Management”, New York, Van Nostrand, 1973
11. George Tchobanoglous, Hilary Theisen and Samuel Vigil Prsl: Tchobanoglous, George Theisen, Hillary Vigil, Samuel, “Integrated Solid Waste management: Engineering Principles and Management issues”, New York, McGraw Hill, 1993.

**REFERENCES:**

1. C Parker and T Roberts (Ed), Energy from Waste - An Evaluation of Conversion Technologies, Elsevier Applied Science, London, 1985
2. KL Shah, Basics of Solid and Hazardous Waste Management Technology, Prentice Hall, 2000 3. M Datta, Waste Disposal in Engineered Landfills, Narosa Publishing House, 1997
3. G Rich et.al, Hazardous Waste Management Technology, Podvan Publishers, 1987
4. AD Bhide, BB Sundaresan, Solid Waste Management in Developing Countries, INSDOC, New Delhi,1983 FUEL CELL AND

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(i) e-waste Management: From waste to Resource Klaus Hieronymi, Ramzy Kahnat, Eric williams
Tech. & Engg.-2013(Publisher: Earthscan 2013).
(ii) What is the impact of E-waste: Tamara Thompson
(iii) E-waste poses a Health Hazard: Sairudeen Pattazhy

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www.routledge.com
www.amazon.com
www.bookdepository.com
www.ecoactiv.com

## JNTUH COLLEGE OF ENGINEERING HYDERABAD

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## DE-4.6: INTEGRATION OF ENERGY SOURCES

**Prerequisite: Renewable Energy Sources**

**Learning Objectives:** Upon successful completion of the course the students will be familiar with:

- To introduce the characteristics of various types of renewable energy sources and converters.
- To explain the importance of storage and sizing of hybrid systems.
- To introduce the control issues of isolated systems.
- To explain the harmonics, power quality, voltage imperfections, power injection issues on the grid by integrating renewable energy sources.

**Learning Outcomes:** At the end of the course, the student should be able to:

- Identify the characteristics of renewable energy sources and converters.
- Analyze the importance of storage and sizing of hybrid systems.
- Realize the problems related to isolated systems.
- Analyze the challenges faced by the grid by integrating renewable energy sources.

**UNIT- I:**
**Review of characteristics of power sources:** Basic review of power generation from wind - Solar PV - Thermal - Small hydro - Biomass power strategies in each of these energy conversion systems - Review of maximum power point tracking techniques in solar PV and wind (perturb & observe, hill climbs, incremental conductance).

**UNIT-II:**
**Converter Topologies:** DC/DC converter (buck, boost, buck boost) - DC/AC inverters (sine, triangular, PWM techniques) - Phase locked loop for inverters.

**UNIT-III:**
**Hybrid Systems:** Advantages of hybrid power systems - Importance of storage in hybrid power systems - Design of hybrid power system based on load curve - Sizing of hybrid power systems.

**UNIT-IV:**
**Isolated Systems:** Control issues in isolated systems for voltage and frequency - Small signal stability in isolated power systems - Importance of storage and dump load in isolated systems.

**UNIT-V:**
**Issues in integration of renewable energy sources:** Overview of challenges in integrating renewable sources to the grid - Impact of harmonics on power quality - Need to maintain voltage within a band and fluctuations in voltage because of renewable integration - Power inverter and converter technologies - Mechanism to synchronize power from renewable sources to the grid - Overview of challenges faced in designing power injection from offshore generation sources - Challenges in modeling intermittent nature of renewable power in a power system.

**TEXT BOOKS:**

1. Power Electronics, Converters, Applications and Design" by N. Mohan; T.M. Undeland; W.P. Robbins. 1995, John Wiley and Sons.
2. Renewable Energy Integration Challenges and Solutions Series: Green Energy and Technology **Hossain**, Jahangir, **Mahmud**, Apel (Eds.)
3. Integration of Alternative Sources of Energy Felix A. Farret, M. Godoy Simões, December 2005, Wiley-IEEE Press.

## JNTUH COLLEGE OF ENGINEERING HYDERABAD

**M.Tech. (PTPG) III-Sem (PE&ID)**

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### ADVANCED POWER ELECTRONIC CONVERTERS
### (Core Theory – 3)

**Prerequisite: Power Electronics**

**Course Objectives:**

- To understand various advanced power electronics devices.
- To describe the operation of multi level inverters with switching strategies for high power applications.
- To comprehend the design of resonant converters and switched mode power supplies.

**Course Outcomes:** After taking this course, student will be able to:

- Develop and analyze various converter topologies.
- Design AC or DC switched mode power supplies.

**UNIT I: MODERN POWER SEMICONDUCTOR DEVICES**

Modern power semiconductor devices – Insulated Gate Bipolar Transistor (IGBT) – MOSFET-MOS Turn off Thyristor (MTO) – Emitter Turn Off Thyristor (ETO) – Integrated Gate-Commutated Thyristor (IGCTs) – MOS-controlled thyristors(MCTs)– Power integrated circuits (PICs) – symbol, structure and equivalent circuit – comparison of their features.

**UNIT II: RESONANT PULSE INVERTERS**

Resonant pulse inverters – series resonant inverters – series resonant inverters with unidirectional switches – series resonant inverters with bidirectional switches – analysis of half bridge resonant inverter – evaluation of currents and voltages of a simple resonant inverter – analysis of half bridge and full bridge resonant inverter with bidirectional switches – Frequency response of series resonant inverters – for series loaded inverter – for parallel loaded inverter – For series and parallel loaded inverters – parallel resonant inverters – Voltage control of resonant inverters – class E resonant inverter – class E resonant rectifier – evaluation of values of *C*'s and *L's* for class E inverter and Class E rectifier – numerical problems.

**UNIT III: RESONANT CONVERTERS**

Resonant converters – zero current switching resonant converters – L type ZCS resonant converter – M type ZCS resonant converter – zero voltage switching resonant converters – comparison between ZCS and ZVS resonant converters – Two quadrant ZVS resonant converters – resonant dc-link inverters – evaluation of L and C for a zero current switching inverter – Numerical problems.

**UNIT IV: MULTILEVEL INVERTERS**

Multilevel concept – Classification of multilevel inverters – Diode clamped Multilevel inverter – principle of operation – main features – improved diode Clamped inverter – principle of operation – Flying capacitors multilevel inverter-principle of operation – main features – cascaded multilevel inverter – principle of operation – main features – Multilevel inverter applications – reactive power compensation – back to back intertie system – adjustable drives -Switching device currents – dc link capacitor voltage balancing – features of Multilevel inverters – comparisons of multilevel converters.

**UNIT V: D.C & A.C POWER SUPPLIES**

DC power supplies – classification - switched mode dc power supplies – fly back Converter – forward converter – push-pull converter – half bridge converter – Full bridge converter – Resonant d c power supplies – bidirectional power supplies – Applications.

AC power supplies – classification – switched mode ac power supplies – Resonant AC power supplies – bidirectional ac power supplies – multistage conversions – control circuits – applications. Introduction – power line disturbances – power conditioners – Uninterruptible Power supplies – applications.

**TEXT BOOKS:**

1. Mohammed H. Rashid –"Power Electronics"– Pearson Education- Third Edition – first Indian reprint -2004.
2. Ned Mohan, Tore M. Undeland and William P. Robbins- "Power Electronics"– John Wiley & Sons – Second Edition.

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## DE – 5.1: DYNAMICS OF ELECTRICAL MACHINES

**Prerequisite: Machine Modeling and Analysis**

**Course Objectives:**

- To introduce generalized modeling electrical machines
- To analyze different electrical machines with dynamic modeling

**Course Outcomes:** After taking this course, the student will be able to:

- Understand the basic mathematical analysis of electrical machines and its characteristics.
- Understand behavior of electrical machines under steady state and transient state.
- Understand dynamic modeling of electrical machines.

**UNIT-I: BASIC MACHINE THEORY**

Electromechanical Analogy – Magnetic Saturation – Rotating field theory – Operation of Inductor motor – equivalent circuit – Steady state equations of DC machines – operations of synchronous motor – Power angle characteristics

**UNIT-II: ELECTRODYNAMICAL EQUATION & THEIR SOLUTIONS**

Spring and Plunger system - Rotational motion – mutually coupled coils – Lagrange's equation – Application of Lagrange's equation solution of Electro dynamical equations.

**UNIT-III: DYNAMICS OF DC MACHINES**

Separately excited d.c. generations – stead state analysis – transient analysis – Separately excited d. c. motors – stead state analysis – transient analysis – interconnection of machines – Ward Leonard system of speed control.

**UNIT-IV: INDUCTION MACHINE DYNAMICS**

Induction machine dynamics during starting and braking – accelerating time – induction machine dynamic during normal operation – Equation for dynamical response of the induction motor.

**UNIT-V: SYNCHRONOUS MACHINE DYNAMICS**

Electromechanical equation – motor operation – generator operation – small oscillations – general equations for small oscillations – representation of the oscillation equations in state variable form.

**TEXT BOOKS:**

1. Sen Gupta D.P. and J.W ‟ Electrical Machine Dynamics "Macmillan Press Ltd 1980.
2. Bimbhra P.S. "Generalized Theory of Electrical Machines " Khanna Publishers 2002.

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## DE – 5.2: SPECIAL MACHINES

**Prerequisite: Electrical Machines**

**Course Objectives:**

- To learn the constructional features, principle of operation, methods of control and applications of stepper motors.
- To understand the constructional features, principle of operation, methods of control and applications of Switched reluctance motors.
- To have an insight into the constructional features, principle of operation, methods of control and applications of PMBLDC motors.
- To know about the types, the constructional features, principle of operation, methods of control and applications of PMSM.
- To gain knowledge in the types, the constructional features, principle of operation, methods of control and applications of Synchronous machine.

**Course Outcomes:** At the end of the course, the student is able to:

- Realize the need for stepper motors and the various applications in industries.
- Draw the operational characteristics and the applications of SRM.
- Know the various types of PMBLDC motors, rotor position sensors, methods of control and their applications.
- Know features, control and the applications of various special machines.

**UNIT–I: STEPPER MOTORS**

Introduction-synchronous inductor (or hybrid stepper motor), Hybrid stepping motor, construction, principles of operation, energization with two phase at a time- essential conditions for the satisfactory operation of a 2-phase hybrid step motor - very slow - speed synchronous motor for servo control-different configurations for switching the phase windings-control circuits for stepping motors-an open-loop controller for a 2-phase stepping motor.

**UNIT-II: VARIABLE RELUCTANCE STEPPING MOTORS**

Variable reluctance ( VR ) Stepping motors, single-stack VR step motors, Multiple stack VR motors-Open-loop control of 3-phase VR step motor-closed-Loop control of step motor, discriminator (or rotor position sensor) transilator, major loop-characteristics of step motor in open-loop drive – comparison between open-loop position control with step motor and a position control servo using a conventional ( dc or ac ) servo motor- Suitability and areas of application of stepping motors-5- phase hybrid stepping motor - single phase - stepping motor, the construction, operating principle torque developed in the motor.

**SWITCHED RELUCTANCE MOTOR:** Introduction – improvements in the design of conventional reluctance motors- Some distinctive differences between SR and conventional reluctance motors - principle of operation of SRM- Some design aspects of stator and rotor pole arcs, design of stator and rotor and pole arcs in SR motor-determination of $L(\theta)$-$\theta$ profile - power converter for SR motor - A numerical example – Rotor sensing mechanism and logic control, drive and power circuits, position sensing of rotor with Hall problems-derivation of torque expression, general linear case.

**UNIT–III: PERMANENT MAGNET MATERIALS AND PMDC MACHINES**

Introduction, Hysteresis loops and recoil line- stator frames (pole and yoke **-** part) of conventional PM dc Motors, Equivalent circuit of PM Generator and Motor-Development of Electronically commutated dc motor from conventional dc motor.

**BRUSHLESS DC MOTOR:** Types of construction – principle of operation of BLDM- sensing and switching logic scheme, sensing logic controller, lockout pulses –drive and power circuits, Base drive circuits, power converter circuit-Theoretical analysis and performance prediction, modeling and magnet circuit d-q analysis of BLDM -transient analysis formulation in terms of flux linkages as state variables-Approximate solution for current and torque under steady state –Theory of BLDM as variable speed synchronous motor ( assuming sinusoidal flux distribution )- Methods or reducing Torque Pulsations, 180 degrees pole arc and 120 degree current sheet.

**UNIT-IV: LINEAR INDUCTION MOTOR**

Development of a double sided LIM from rotary type IM- A schematic of LIM drive for electric traction development of one sided LIM with back iron-field analysis of a DSLIM fundamental assumptions.

**UNIT-V: PERMANENT MAGNET AXIAL FLUX (PMAF) MACHINES**

Construction, Armature windings – Toroidal Stator and Trapezoidal Stator Windings, Torque and EMF equations, Phasor diagram and output equation.

**TEXT BOOKS:**

1. Special electrical machines, K. Venkataratnam, - University press.
2. Special electrical machines, E. G. Janardanan, - PHI.

**REFERENCES:**

1. R. K. Rajput, “Electrical machines” – 5$^{th}$ edition.
2. V. V. Athani, “Stepper motor: Fundamentals, Applications and Design”, New age International publishers.
3. Switched Reluctance Motor Drives by R. Krishnan, CRC Press,

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## DE – 5.3: SMART GRID TECHNOLOGIES

**Prerequisite: None**

**Course Objectives:**

- To group various aspects of the smart grid,
- To defend smart grid design to meet the needs of a utility
- To select issues and challenges that remain to be solved
- To analyze basics of electricity, electricity generation, economics of supply and demand, and the various aspects of electricity market operations in both regulated and deregulated environment.

**Course Outcomes:** Upon the completion of this course, the student will be able to

- Analyze the structure of an electricity market in either regulated or deregulated market conditions.
- Know the advantages of DC distribution and developing technologies in distribution
- Discriminate the trade-off between economics and reliability of an electric power system.
- Differentiate various investment options (e.g. generation capacities, transmission, renewable, demand-side resources, etc) in electricity markets.
- Analyze the development of smart and intelligent domestic systems.

**UNIT–I: INTRODUCTION**

Introduction to smart grid - Electricity network - Local energy networks- Electric transportation - Low carbon central generation - Attributes of the smart grid - Alternate views of a smart grid.

**SMART GRID TO EVOLVE A PERFECT POWER SYSTEM:** Introduction- Overview of the perfect power system configurations- Device level power system- Building integrated power systems- Distributed power systems- Fully integrated power system-Nodes of innovation.

**UNIT–II: DC DISTRIBUTION AND SMART GRID**

AC Vs DC sources-Benefits of and drives of DC power delivery systems - Powering equipment and appliances with DC-Data centers and information technology loads - Future neighborhood-Potential future work and research.

**INTELLIGRID ARCHITECTURE FOR THE SMARTGRID:** Introduction- Launching intelligent grid –Intelligent grid today - Smart grid vision based on the intelligent grid architecture-Barriers and enabling technologies.

**UNIT–III: DYNAMIC ENERGY SYSTEMS CONCEPT**

Smart energy efficient end use devices-Smart distributed energy resources - Advanced whole building control systems- Integrated communications architecture - Energy management-Role of technology in demand response- Current limitations to dynamic energy management-Distributed energy resources-Overview of a dynamic energy management-Key characteristics of smart devices- Key characteristics of advanced whole building control systems-Key characteristics of dynamic energy management system.

**UNIT–IV: ENERGY PORT AS PART OF THE SMART GRID:**

Concept of energy - Port, generic features of the energy port.

**POLICIES AND PROGRAMS TO ENCOURAGE END – USE ENERGY EFFICIENCY:** Policies and programs in action - multinational - national-state-city and corporate levels.
**MARKET IMPLEMENTATION:** Framework-factors influencing customer acceptance and response - program planning - monitoring and evaluation.

**UNIT–V: EFFICIENT ELECTRIC END–USE TECHNOLOGY ALTERNATIVES**
Existing technologies – lighting - Space conditioning - Indoor air quality - Domestic water heating - hyper efficient appliances - Ductless residential heat pumps and air conditioners - Variable refrigerant flow air conditioning-Heat pump water heating - Hyper efficient residential appliances - Data center energy efficiency- LED street and area lighting - Industrial motors and drives - Equipment retrofit and replacement - Process heating - Cogeneration, Thermal energy storage - Industrial energy management programs - Manufacturing process-Electro-technologies, Residential, Commercial and industrial sectors.

**TEXT BOOKS:**
1. Clark W Gellings, “The Smart Grid, Enabling Energy Efficiency and Demand Side Response”- CRC Press, 2009.
2. Jean Claude Sabonnadière, NouredineHadjsaïd, “Smart Grids”, Wiley-ISTE, IEEE Press, May 2012

**REFERENCES:**
1. Janaka Ekanayake, KithsiriLiyanage, Jianzhong.Wu, Akihiko Yokoyama, Nick Jenkins, “Smart Grid: Technology and Applications”- Wiley, 2012.
2. James Momoh, “Smart Grid: Fundamentals of Design and Analysis” - Wiley, IEEE Press, 2012.

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**M.Tech. (PTPG) III-Sem (PE&ID)**

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## DE – 6.1: FLEXIBLE AC TRANSMISSION SYSTEMS

**Prerequisite: Power Electronics and Power Systems**

**Course Objectives:**

- To develop the understanding of uncompensated lines and their behavior under heavy loading conditions.
- To understand the concept and importance controllable parameters of FACTS controllers.
- To emphasize the objectives of Shunt compensation, and basic operation of SVC and STATCOM.
- To analyze the functioning of series controllers like GCSC, TSSC and TCSC

**Course Outcomes:** Upon the completion of this course, the student will be able to

- Choose proper controller for the specific application based on system requirements
- Understand various systems thoroughly and their requirements
- Interpret the control circuits of Shunt Controllers SVC & STATCOM for various functions viz. Transient stability Enhancement, voltage instability prevention and power oscillation damping
- Detect the Power and control circuits of Series Controllers GCSC, TSSC and TCSC

**UNIT-I: FACTS CONCEPTS**

Transmission interconnections power flow in an AC system, loading capability limits, Dynamic stability considerations, importance of controllable parameters basic types of FACTS controllers, benefits from FACTS controllers.

**UNIT-II: VOLTAGE SOURCE CONVERTERS**

Single phase three phase full wave bridge converters transformer connections for 12 pulse 24 and 48 pulse operation. Three level voltage source converter, pulse width modulation converter, basic concept of current source Converters, and comparison of current source converters with voltage source converters.

**UNIT-III: STATIC SHUNT COMPENSATION**

Objectives of shunt compensation, mid-point voltage regulation voltage instability prevention, improvement of transient stability, Power oscillation damping, Methods of controllable VAR generation, variable impedance type static VAR generators switching converter type VAR generators hybrid VAR generators.

**UNIT-IV: SVC AND STATCOM**

The regulation and slope transfer function and dynamic performance, transient stability enhancement and power oscillation damping operating point control and summary of compensator control.

**UNIT-V: STATIC SERIES COMPENSATORS**

Concept of series capacitive compensation, improvement of transient stability, power oscillation damping, and functional requirements of GTO thyristor controlled series capacitor (GSC), thyristor switched series capacitor (TSSC), and thyristor controlled series capacitor (TCSC)

Control schemes for GSC TSSC and TCSC.

**TEXT BOOKS:**

1. Hingorani H G and Gyugyi. L " Understanding FACTS-Concepts and Technology of Flexible AC Transmission Systems" New York, IEEE Press, 2000.
2. Padiyar.K.R, " FACTS Controllers in Power Transmission and Distribution" New Age Int. Publishers, 2007

**REFERENCES:**

1. Zhang, Xiao-Ping, Rehtanz, Christian, Pal, Bikash "Flexible AC Transmission Systems: Modeling and Control", Springer, 2012
2. Yong-Hua Song, Allan Johns, "Flexible AC Transmission Systems", IET, 1999.

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## DE – 6.2: SWITCHED MODE POWER SUPPLIES

**Prerequisite: Power Electronic Devices and circuits**

**Course Objectives:**

- To apply the basic concepts of power electronics for designing converters.
- Design and implement practical circuits for UPS, SMPS etc.

**Course Outcomes:** After taking this course, student will be able to:

- Design converter system for electrical applications
- Understand and design SMPS.

**UNIT – I**
**BASIC CONVERTER CIRCUITS:**
Buck Regulator, Buck- Boost Regulator, Boost Regulator, Cuk Converters and Resonant Converters. Choice of switching frequency.

**UNIT – II**
**ISOLATED SMPS:**
Fly back Converter, Forward Converter, Half-Bridge and Full Bridge Converters, Push-Pull Converter and SMPS with multiple outputs. Choice of switching frequency.

**UNIT – III**
**CONTROL ASPECTS**
PWM Controllers, Isolation in feedback loop, Power Supplies with multiple output.
Stability analysis using Bode Diagrams.

**UNIT – IV**
**DESIGN CONSIDERATIONS**
Selection of output filter capacitor, Selection of energy storage inductor, Design of High Frequency Inductor and High frequency Transformer, Selection of switches. Snubber circuit design, Design of driver circuits.

**UNIT – V**
**ELECTRO MAGNETIC INTERFERENCE (EMI)**
EMI Filter Components, Conducted EMI suppression, Radiated EMI suppression, Measurement.
**PROTECTION**
Over current protection, Over voltage protection, Inrush current protection.
**THERMAL MODEL**
Thermal Resistance, Cooling Considerations, Selection of Heat sinks, Simple Heat sink calculations.

**TEXT BOOKS:**

1. Switched Mode Power Supplies, Design and Construction, H. W. Whittington, B. W. Flynn and D. E. MacPherson, Universities Press, 2009 Edition.
2. Mohan N. Undeland . T & Robbins W, Power Electronics Converters, Application and Design. John Wiley, 3rd edition, 2002

3. Umanand L., Bhat S.R., Design of magnetic components for switched Mode Power Converters. , Wiley Eastern Ltd.,1992
4. Robert. W. Erickson, D. Maksimovic .Fundamentals of Power Electronics., Springer International Edition, 2005
5. Course Material on Switched Mode Power Conversion, V. Ramanarayanan.

**REFERENCES:**

1. Krein P.T .Elements of Power Electronics., Oxford University Press
2. M.H.Rashid, Power Electronics. Prentice-Hall of India

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## DE – 6.3: DIGITAL CONTROL SYSTEMS

**Prerequisite: None**

**Course Objectives:**

- To explain basic and digital control system for the real time analysis and design of control systems.
- To apply the knowledge state variable analysis in the design of discrete systems.
- To explain the concept of stability analysis and design of discrete time systems.

**Course Outcomes:** Upon the completion of this course, the student will be able to

- Apply the concepts of Digital control systems.
- Analyze and design of discrete systems in state variable analysis.
- To relate the concepts of stability analysis and design of discrete time systems.

**UNIT – I: Concept & Representation of Discrete time Systems**

Block Diagram of typical control system- advantages of sampling in control systems – examples of discrete data and digital systems – data conversion and quantization – sample and hold devices – D/A and A/D conversion – sampling theorem – reconstruction of sampled signals.

**Z-transform:** Definition of Z-transforms – mapping between s-plane and z-plane – inverse z-transform – properties of z-transforms - ROC of z-transforms –pulse transfer function –relation between G(s) and G(z) – signal flow graph method applied to digital control systems.

**UNIT- II: STATE SPACE ANALYSIS:**

State space modeling of discrete time systems – state transition equation of discrete time invariant systems – solution of time invariant discrete state equations: recursive method and the Z-Transformation method – conversion of pulse transfer function to the state model & vice-versa – Eigen values – Eigen vectors of discrete time system-matrix (A) – Realization of pulse transformation in state space form, discretization of continuous time systems, Computation of state transition matrix and its properties. Response of sample data system between sampling instants.

**UNIT – III: Controllability, Observability & Stability tests**

Concept of controllability, stabilizability, observability and reachability - Controllability and observability tests, Transformation of discrete time systems into controllable and observable forms.

Stability: Definition of stability – stability tests – The second method of Liapunov.

**UNIT- IV: Design of discrete time Controllers and observers**

Design of discrete time controller with bilinear transformation – Realizatiion of digital PID controller-Design of deadbeat controller; Pole placement through state feedback.

**UNIT-V: STATE OBSERVERS:**

Design of - Full order and reduced order observers. Study of observer based control design

**TEXT BOOKS:**

1. K. Ogata , Discrete-Time Control systems, Pearson Education/PHI, 2nd Edition.
2. V. I. George, C. P. Kurian, Digital Control Systems, Cengage Learning.
3. M.Gopal, Digital Control Engineering, New Age Int. Pvt. Ltd., 2014

**REFERENCES:**

1. Kuo, Digital Control Systems, Oxford University Press, 2nd Edition, 2003.
2. M.Gopal , Digital Control and State Variable Methods, TMH.
3. M. Sami Fadali Antonio Visioli, Digital Control Engineering Analysis and Design, Academic Press

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## POWER CONVERTERS LAB

1. Speed control of separately excited DC Motor Drive with 1 quadrant chopper
2. Speed control of separately excited DC Motor Drive with 4 quadrant chopper.
3. Speed control of BLDC Motor Drive.
4. Multi-level inverter based AC Induction Motor Drive control equipment.
5. Speed control of 3-phase wound rotor Induction Motor Drive.
6. Speed control of 3-phase doubly fed Induction Motor Drive.
7. Speed control of 5-phase Induction Motor Drive.
8. Speed control of 3-phase Induction Motor Drive using V/F control.
9. Speed control of 3-phase Induction Motor Drive using Vector Control technique.
10. Speed Measurement and closed loop control using PMDC Motor Drive.
11. Speed measurement and closed loop control of PMDC Motor Drive with thyristor circuit.
12. Matrix Converter
13. Speed measurement and closed loop control of IGBT used single 4 quadrant chopper for PMDC Motor Drive.
14. Isolated Gate Drive circuits for MOSFET / IGBT based circuits.

**Note:** Any ten experiments can be conducted.

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### POWER ELECTRONIC CONTROL OF AC DRIVES
### (Core Theory – 4)

**Prerequisite: Power Electronic Devices and Circuits**

**Course Objectives:**

- To understand principle operation of scalar control of ac motor and corresponding speed-torque characteristics
- To comprehend the vector control for ac motor drive (IM and SM)
- To explain the static resistance control and Slip power recovery drive
- To explain synchronous motor drive characteristics and its control strategies
- To comprehend the brushless dc motor principle of operation.

**Course Outcomes:** After taking this course, student will be able to:

- Develop induction motor for variable speed operations using scalar and vector control techniques.
- Identify the difference between the rotor resistance control and static rotor resistance control method and significance of slip power recovery drives.
- Develop controllers for synchronous motor and variable reluctance motor.

**UNIT-I:**

**INTRODUCTION:** Introduction to motor drives – Torque production – Equivalent circuit analysis – Speed – Torque Characteristics with variable voltage operation Variable frequency operation constant v/t operation – Variable stator current operation – Induction motor characteristics in constant torque and field weakening regions.

**STATOR SIDE CONTROL OF INDUCTION MOTOR DRIVES**

Scalar control – Voltage fed inverter control – Open loop volts/Hz control – speed control slip regulation – speed control with torque and flux control – current controlled voltage fed inverter drive – current – fed inverter control – Independent current and frequency control – Speed and flux control in Current –Fed inverter drive – Volts/Hz control of Current –fed inverter drive – Efficiency optimization control by flux program – closed loop operation.

**UNIT–II: ROTOR SIDE CONTROL OF INDUCTION MOTOR DRIVES**

Slip power recovery drives – Static Kramer Drive – Phasor diagram – Torque expression – speed control of Kramer Drive – Static Scheribus Drive – modes of operation.

**UNIT–III:**

**CONTROL OF SYNCHRONOUS MOTOR DRIVES:** Synchronous motor and its characteristics – Control strategies – Constant torque angle control – Unity power factor control – Constant mutual flux linkage control – closed loop operation.

**Controllers:** Flux weakening operation – Maximum speed – Direct flux weakening algorithm – Constant Torque mode controller – Flux Weakening controller – indirect flux weakening – Maximum permissible torque – speed control scheme – Implementation strategy speed controller design.

**UNIT–IV:**

**VARIABLE RELUCTANCE MOTOR DRIVE:** Variable Reluctance motor drive – Torque production in the variable reluctance motor Drive characteristics and control principles – Current control variable reluctance motor service drive.

**PMSM & BRUSHLESS DC MOTOR DRIVES:** Three phase full wave Brushless dc motor – Sinusoidal type of Brushless dc motor- current controlled Brushless dc motor Servo drive.

**UNIT–V:**

**VECTOR CONTROL OF INDUCTION MOTOR DRIVES:** Principles of Vector control – Vector control methods – Direct methods of vector control – Indirect methods of vector control – Adaptive control principles – Self tuning regulator Model referencing control – Direct torque control of AC motors.

**TEXT BOOKS:**

1. Electric Motor Drives Pearson Modeling, Analysis and control – R. Krishnan – Publications – 1st edition – 2002.
2. Modern Power Electronics and AC Drives B K Bose – Pearson Publications 1st edition
3. Power Electronics and Control of AC Motors – MD Murthy and FG Turn Bull Pergman Press 1st edition

**REFERENCES:**

1. Power Electronics and AC Drives – BK Bose – Prentice Hall Eagle wood diffs New Jersey - 1st edition
2. Power Electronic circuits Deices and Applications – M H Rashid – PHI – 1995.
3. Fundamentals of Electrical Drives – G. K. Dubey – Narosa publications – 1995.

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## DE – 7.1: POWER QUALITY

**Prerequisite: Power Systems**

**Course Objectives:**

- To Study the basics of power quality , power quality problems and power quality standards,
- To Study about the characteristics of non-linear loads
- To Study Voltage, Current, Power and Energy measurements and analysis methods of Laplace's, Fourier and Hartley and Wavelet Transforms
- To Study the analysis and conventional mitigation methods
- To Study about various devices used to enhance power quality.

**Course Outcomes:** After taking this course, the student will be able to:

- Know the different characteristics of electric power quality in power systems,
- Learn about the applications of non-linear loads ,
- Know the applications of Hartley and Wavelet Transforms ,
- Learn how to mitigate the power quality problems
- Learn about the application of FACTS device on DG side.

**UNIT-I:**
**INTRODUCTION**
Introduction of the Power Quality (PQ) problem, Terms used in PQ: Voltage, Sag, Swell, Surges, Harmonics, over voltages, spikes, Voltage fluctuations, Transients, Interruption, overview of power quality phenomenon, Remedies to improve power quality, power quality monitoring.

**UNIT-II:**
**LONG & SHORT INTERRUPTIONS**
Interruptions – Definition – Difference between failures, outage, Interruptions – causes of Long Interruptions – Origin of Interruptions – Limits for the Interruption frequency – Limits for the interruption duration – costs of Interruption – Overview of Reliability evaluation to power quality, comparison of observations and reliability evaluation.
**Short interruptions**: definition, origin of short interruptions, basic principle, fuse saving, voltage magnitude events due to re-closing, voltage during the interruption, monitoring of short interruptions, difference between medium and low voltage systems. Multiple events, single phase tripping – voltage and current during fault period, voltage and current at post fault period, stochastic prediction of short interruptions.

**UNIT III:**
**SINGLE AND THREE-PHASE VOLTAGE Sag CHARACTERIZATION**
Voltage sag – definition, causes of voltage sag, voltage sag magnitude, and monitoring, theoretical calculation of voltage sag magnitude, voltage sag calculation in non-radial systems, meshed systems, and voltage sag duration.
Three phase faults, phase angle jumps, magnitude and phase angle jumps for three phase unbalanced sags, load influence on voltage sags.

**UNIT-IV:**

**POWER QUALITY CONSIDERATIONS IN INDUSTRIAL POWER SYSTEMS**

Voltage sag – equipment behavior of Power electronic loads, induction motors, synchronous motors, computers, consumer electronics, adjustable speed AC drives and its operation. Mitigation of AC Drives, adjustable speed DC drives and its operation, mitigation methods of DC drives.

**UNIT-V:**

**MITIGATION OF INTERRUPTIONS & VOLTAGE SAGS**

Overview of mitigation methods – from fault to trip, reducing the number of faults, reducing the fault clearing time changing the power system, installing mitigation equipment, improving equipment immunity, different events and mitigation methods. System equipment interface – voltage source converter, series voltage controller, shunt controller, combined shunt and series controller.

**Power Quality and EMC Standards:**

Introduction to standardization, IEC Electromagnetic compatibility standards, European voltage characteristics standards, PQ surveys.

**TEXT BOOKS:**

1. "Understanding Power Quality Problems" by Math H J Bollen. IEEE Press.
2. "Power Quality VAR Compensation in Power Systems", R. SastryVedam Mulukutla S. Sarma,CRC Press.

**REFERENCES:**

1. Power Quality, C. Sankaran, CRC Presss.
2. Electrical Power Systems Quality, Roger C. Dugan , Mark F. Mc Granaghan, Surya Santoso, H. Wayne Beaty, Tata McGraw Hill Education Private Ltd.

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## DE – 7.2: SOLAR PHOTO VOLTAIC SYSTEMS

**Pre-requisite: None**

**Course Objectives:** Objectives of this course are
To introduce photovoltaic systems
To deal with various technologies of solar PV cells
To understand details about manufacture, sizing and operating techniques
To have knowledge of design considerations.

**Course Outcomes:** After this course, the student will be able to
- Identify photovoltaic system components and system types
- Calculate electrical energy and power
- Correctly size system components, design considerations of solar equipment
- Design a basic grid-tie PV system.

**UNIT – I**
**SOLAR ENERGY:** Sun and Earth, Solar Spectrum, Solar Geometry, Solar radiation on horizontal and inclined planes, Instruments for measurement of solar radiation ,Solar cell, Equivalent circuit, V-I characteristics, Performance improvement.

**UNIT – II**
**SOLAR CELLS:** Manufacture of Solar Cells-Technologies, Design of Solar cells, Photovoltaic modules, Design requirements, encapsulation systems, manufacture, power rating, hotspot effect, Design qualifications.

**UNIT – III**
**PROTECTION AND MEASUREMENTS:** Flat plate arrays, support structures, module interconnection and cabling, lightning protection, Performance measurement – using natural sun light and simulator, determination of temperature coefficients, internal series resistance, curve correction factor.

**UNIT - IV**
**PHOTOVOLTAIC SYSTEMS:** Photovoltaic systems- types- general design considerations-system sizing-battery sizing- inverter sizing-design examples – Balance of PV systems.

**UNIT – V**
**MAXIMUM POWER POINT TRACKERS:** Maximum power point trackers-algorithms-perturb and observe-incremental conductance method, hill climbing method, , hybrid and complex methods, data based and other approximate methods, instrument design, other MPP techniques-Grid interactive PV system.

**TEXT BOOKS:**
1. Generating electricity from Sun, F.C.Treble, Pergamon Press
2. Photvolatic systems: Analysis and design, A.K.Mukherjee, Nivedita Thakur, PHI 2011
3. Solar Photovoltaics: Fundamentals, Technologies and applications, C.S.Solanki, PHI, 2009

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## DE – 7.3: HYBRID ELECTRIC VEHICLES

**Pre-requisites:**

1. Control Systems Engineering – I.
2. Electrical Machines-I.
3. Electrical Machines-II.
4. Power Electronics

**COURSE OUTLINE:**

This course introduces the fundamental concepts, principles, analysis and design of hybrid and electric vehicles.

The material for this course will be prepared in such a manner that it will be useful for post-graduate students, teachers, practitioners and final year undergraduate students.

This course goes deeper into the various aspects of hybrid and electric drive train such as their configuration, types of electric machines that can be used, energy storage devices, etc. Each topic will be developed in logical progression with up-to-date information.

A number of chosen problems will be solved to illustrate the concepts clearly. There shall be a suite of exercises based on MATLAB and Simulink.

**UNIT-I:**

Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies.

Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, and mathematical models to describe vehicle performance.

**UNIT-II:**

Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.

Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.

**UNIT-III:**

Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

**UNIT-IV:**

Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices.

Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems

**UNIT-V:**

Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies.

**REFERENCES:**

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design fundamentals, CRC Press, 2003.
2. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
3. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).

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## DE – 8.1: PROGRAMMABLE LOGIC CONTROLLERS AND APPLICATIONS

**Prerequisite: None**

**Course Objectives:**

- To provide and ensure a comprehensive understanding of using advanced controllers in measurement and control instrumentation.
- To illustrate about data acquisition - process of collecting information from field instruments.
- To analyze Programmable Logic Controller (PLC), IO Modules and internal features.
- To Comprehend Programming in Ladder Logic, addressing of I/O.
- To apply PID and its Tuning.

**Course Outcomes:** Upon the completion of this course, the student will be able to

- Describe the main functional units in a PLC and be able to explain how they interact.
- They should know different bus types used in automation industries.
- Development of ladder logic programming for simple process.

**UNIT-I:**
PLC Basics PLC system, I/O modules and interfacing CPU processor programming equipment programming formats, construction of PLC ladder diagrams, devices connected to I/O modules.

**UNIT-II:**
PLC Programming input instructions, outputs, operational procedures, programming examples using contacts and coils. Drill-press operation.
Digital logic gates programming in the Boolean algebra system, conversion examples Ladder diagrams for process control Ladder diagrams and sequence listings, ladder diagram construction and flow chart for spray process system.

**UNIT-III:**
PLC Registers: Characteristics of Registers module addressing holding registers input registers, output registers. PLC Functions Timer functions and industrial applications counters counter function industrial applications, Architecture functions, Number comparison functions, number conversion functions.

**UNIT-IV:**
Data handling functions: SKIP, Master control Relay Jump Move FIFO, FAL, ONS, CLR and Sweep functions and their applications. Bit Pattern and changing a bit shift register, sequence functions and applications, controlling of two axes and three axis Robots with PLC, Matrix functions.

**UNIT-V:**
Analog PLC operation: Analog modules and systems Analog signal processing multi bit data processing , analog output application examples, PID principles position indicator with PID control, PID modules, PID tuning, PID functions

**TEXT BOOKS:**

1. Programmable Logic Controllers – Principle and Applications by John W. Webb & Ronald A. Reiss, Fifth Edition, PHI
2. Digital Design by Morris Mano, PHI, 3rd Edition 2006.

**REFERENCES:**

1. Programmable logic Controllers, Frank D. Petruzella, 4th Edition, McGraw Hill Publishers.
2. Programmable Logic Controllers – Programming Method and Applications by JR. Hackworth & F.D Hackworth Jr. – Pearson, 2004.
3. Programmable logic controllers and their Engineering Applications, 2nd Edition, Alan J. Crispin.

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## DE – 8.2: AI TECHNIQUES IN ELECTRICAL ENGINEERING

**Prerequisite: None**

**Course Objectives:**

- To locate soft commanding methodologies, such as artificial neural networks, Fuzzy logic and genetic Algorithms.
- To observe the concepts of feed forward neural networks and about feedback neural networks.
- To practice the concept of fuzziness involved in various systems and comprehensive knowledge of fuzzy logic control and to design the fuzzy control
- To analyze genetic algorithm, genetic operations and genetic mutations.

**Course Outcomes:** Upon the completion of this course, the student will be able to

- Understand feed forward neural networks, feedback neural networks and learning techniques.
- Understand fuzziness involved in various systems and fuzzy set theory.
- Develop fuzzy logic control for applications in electrical engineering
- Develop genetic algorithm for applications in electrical engineering.

**UNIT – I: ARTIFICIAL NEURAL NETWORKS**

Introduction-Models of Neural Network - Architectures – Knowledge representation – Artificial Intelligence and Neural networks – Learning process – Error correction learning – Hebbian learning – Competitive learning – Boltzman learning – Supervised learning – Unsupervised learning – Reinforcement learning - learning tasks.

**UNIT- II: ANN PARADIGMS**

Multi – layer perceptron using Back propagation Algorithm-Self – organizing Map – Radial Basis Function Network – Functional link, network – Hopfield Network.

**UNIT – III: FUZZY LOGIC**

Introduction – Fuzzy versus crisp – Fuzzy sets - Membership function – Basic Fuzzy set operations – Properties of Fuzzy sets – Fuzzy cartesian Product – Operations on Fuzzy relations – Fuzzy logic – Fuzzy Quantifiers - Fuzzy Inference - Fuzzy Rule based system - Defuzzification methods.

**UNIT – IV: GENETIC ALGORITHMS**

Introduction-Encoding – Fitness Function-Reproduction operators - Genetic Modeling – Genetic operators - Crossover - Single–site crossover – Two-point crossover – Multi point crossover-Uniform crossover – Matrix crossover - Crossover Rate - Inversion & Deletion – Mutation operator –Mutation – Mutation Rate-Bit-wise operators-Generational cycle-convergence of Genetic Algorithm.

**UNIT–V: APPLICATIONS OF AI TECHNIQUES**

Load forecasting – Load flow studies – Economic load dispatch – Load frequency control – Single area system and two area system – Small Signal Stability (Dynamic stability) Reactive power control – speed control of DC and AC Motors.

**TEXT BOOKS:**

1. S.Rajasekaran and G.A.V.Pai, “Neural Networks, Fuzzy Logic & Genetic Algorithms”- PHI, New Delhi, 2003.

**REFERENCES:**

1. P.D.Wasserman,Van Nostrand Reinhold,’”Neural Computing Theory & Practice”, New York,1989.
2. Bart Kosko, “Neural Network & Fuzzy System”, Prentice Hall, 1992.
3. G.J.Klir and T.A.Folger, “Fuzzy sets, Uncertainty and Information”, PHI, Pvt.Ltd,1994.
4. D.E.Goldberg, “Genetic Algorithms”, Addison Wesley 1999.

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## DE – 8.3. ENERGY EFFICIENT SYSTEMS

**UNIT-I:**
**Electrical System:** Electricity billing, Electrical Load Management and maximum demand control, Power factor improvement and its benefit, Selection and location of capacitors, Performance assessment of PF capacitors, Distribution and Transformer losses.

**UNIT-II:**
**Electric Motors:** Types, Losses in Electric Motors, motor efficiency, factors affecting motor performance, rewinding and motor replacement issues, energy saving opportunities with energy efficient motors **Lighting System:** Light source, choice of lighting, luminance requirements, and energy conservation avenues. Energy efficient lightning controls, comparison of sodium vapor, halogen, CFL and LED lamps.

**UNIT-III:**
**Compressed Air System:** Types of air compressors, compressor efficiency, efficient compressor operation, compressed air system components, capacity assessment, leakage test, factors affecting the performance and savings opportunities. **HVAC and Refrigeration system:** vapor compression refrigeration cycle, refrigerants, coefficient of performance, capacity, factors affecting refrigeration and air-conditioning system performance and saving opportunities, vapor absorption refrigeration system - working principle, types and comparison with vapour compression system, saving potential Fans and Blowers: Types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities.

**UNIT-IV:**
**Pumps and Pumping System:** Types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities. **Cooling Tower:** Types and performance evaluation, efficient system operation, flow control strategies, energy saving opportunities, Assessment of cooling tower.

**UNIT-V:**
**Diesel generating system:** Factors affecting selection, energy performance assessment of diesel conservation avenues. **Energy Efficient Technologies in Electrical Systems:** Maximum Demand Controllers, automatic power factor controllers, energy efficient motors, soft starters with energy saver, variable speed drives, energy efficient transformers, electronic ballast, occupancy sensors, energy saving potential of each technology. Calculation of energy frequency ratio in the performance of star ratings.

**TEXT BOOKS:**
1. Eastop T.D & Croft D.R, Energy Efficiency for Engineers and Technologists,. Logman Scientific & Technical, ISBN-0-582-03184, 1990.
2. Reay D.A, Industrial Energy Conservation, 1stedition, Pergamon Press, 1977.

**REFERENCE:**
1. Larry C Whitetal, Industrial Energy Management & Utilization.
2. Power System Engineering 2nd Ed. D P Kothari, I J Nagrath, Tata McGraw-Hill Co 2008
3. Bureau of Energy Efficiency (BEE) : www.bee-india.nic.in
4. The Energy and Resource Institute (TERI): http://www.teriin.org/

5. Energy Efficiency for Engineers and Technologists, First Edition, 1990, by TD Eastop and DR Croft, Longman Group UK Ltd.
6. Industrial Energy Management and Utilization, 1988, by LC Wittie, P S Schmidt and D R Brown, Hemisphere Publishing Company. 3. Energy Management Hand Book, Third Edition, 1997, by W C Turner, the Fairmont Press Inc.
7. www.bee-india.nic.in (Guide on Energy Efficient room Air conditioners)

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## DE – 8.4: SOFTWARE ENGINEERING

**Prerequisites**
1. A course on "Computer Programming and Data Structures"
2. A course on "Object Oriented Programming Through Java"

**Objectives**
1. The aim of the course is to provide an understanding of the working knowledge of the techniques for estimation, design, testing and quality management of large software development projects.
2. Topics include process models, software requirements, software design, software testing, software process/product metrics, risk management, quality management and UML diagrams

**Outcomes**
1. Ability to translate end-user requirements into system and software requirements, using e.g. UML, and structure the requirements in a Software Requirements Document (SRD).
2. Identify and apply appropriate software architectures and patterns to carry out high level design of a system and be able to critically compare alternative choices.
3. Will have experience and/or awareness of testing problems and will be able to develop a simple testing report

**UNIT-I:**
**Introduction to Software Engineering:** The evolving role of software, changing nature of software, software myths.
**A Generic view of process:** Software engineering- a layered technology, a process framework, the capability maturity model integration (CMMI), process patterns, process assessment, personal and team process models.
**Process models:** The waterfall model, incremental process models, evolutionary process models, the unified process.

**UNIT-II:**
**Software Requirements:** Functional and non-functional requirements, user requirements, system requirements, interface specification, the software requirements document.
**Requirements engineering process:** Feasibility studies, requirements elicitation and analysis, requirements validation, requirements management.
**System models:** Context models, behavioral models, data models, object models, structured methods.

**UNIT-III:**
**Design Engineering:** Design process and design quality, design concepts, the design model.
**Creating an architectural design:** software architecture, data design, architectural styles and patterns, architectural design, conceptual model of UML, basic structural modeling, class diagrams, sequence diagrams, collaboration diagrams, use case diagrams, component diagrams.

**UNIT-IV:**
**Testing Strategies:** A strategic approach to software testing, test strategies for conventional software, black-box and white-box testing, validation testing, system testing, the art of debugging.

**Product metrics:** Software quality, metrics for analysis model, metrics for design model, metrics for source code, metrics for testing, metrics for maintenance.

**UNIT-V:**

**Metrics for Process and Products:** Software measurement, metrics for software quality.

**Risk management:** Reactive Vs proactive risk strategies, software risks, risk identification, risk projection, risk refinement, RMMM, RMMM plan.

**Quality Management:** Quality concepts, software quality assurance, software reviews, formal technical reviews, statistical software quality assurance, software reliability, the ISO 9000 quality standards.

**TEXT BOOKS:**

1. Software Engineering, A practitioner's Approach- Roger S. Pressman, 6th edition, Mc Graw Hill International Edition.
2. Software Engineering- Sommerville, 7th edition, Pearson Education.
3. The unified modeling language user guide Grady Booch, James Rambaugh, Ivar Jacobson, Pearson Education.

**REFERENCES:**

1. Software Engineering, an Engineering approach- James F. Peters, Witold Pedrycz, John Wiely.
2. Software Engineering principles and practice- Waman S Jawadekar, The Mc Graw-Hill Companies.
3. Fundamentals of object oriented design using UML Meiler page-Jones: Pearson Education.

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## DE – 8.5: ENERGY STORAGE TECHNOLOGIES

**UNIT-I: The roles of electrical energy storage technologies in electricity use:** Characteristics of electricity, Electricity and the roles of EES, High generation cost during peak-demand periods,Need for continuous and flexible supply,Long distance between generation and consumption, Congestion in power grids,Transmission by cable, Emerging needs for EES, More renewable energy, less fossil fuel, Smart Grid uses,The roles of electrical energy storage technologies,The roles from the viewpoint of a utility,The roles from the viewpoint of consumers, The roles from the viewpoint of generators of renewable energy.

**UNIT-II: Types and features of energy storage systems:** Classifi cation of EES systems,Mechanical storage systems, Pumped hydro storage (PHS), Compressed air energy storage (CAES), Flywheel energy storage (FES), Electrochemical storage systems, Secondary batteries, Lead-Acid Batteries, Lithium-Ion Batteries, Flow batteries, Other Batteries in Development, Chemical energy storage, Hydrogen (H2), Synthetic natural gas (SNG), Electrical storage systems,Double-layer capacitors (DLC), Superconducting magnetic energy storage (SMES),Thermal storage systems, Standards for EES,Technical comparison of EES technologies.

**UNIT-III: Applications of EES:** Present status of applications, Utility use (conventional power generation, grid operation & service), Consumer use (uninterruptable power supply for large consumers), EES installed capacity worldwide, New trends in applications, Renewable energy generation, Smart Grid, Smart Microgrid, Smart House, Electric vehicles,

**UNIT-IV: Management and control hierarchy of EES:** Internal configuration of battery storage systems, External connection of EES systems, Aggregating EES systems and distributed generation (Virtual Power Plant),“Battery SCADA” – aggregation of many dispersed batteries.
**Demand for Energy Storage:** Growth in Variable Energy Resources, Relationship between balancing services and variable energy resources, Energy Storage Alternatives, Variable Generator Control, Demand Management, Market Mechanisms, Longer Term Outlook.
**Valuation Techniques:** Overview, Energy Storage Operational Optimization, Market Price Method, Power System Dispatch Model Method, Ancillary Service Representation, Energy Storage Representation, Survey of Valuation Results.

**UNIT-IV: Forecast of EES market potential by 2030:** EES market potential for overall applications, EES market estimation by Sandia National Laboratory (SNL), EES market estimation by the Boston Consulting Group (BCG), EES market estimation for Li-ion batteries by the Panasonic Group, EES market potential estimation for broad introduction of renewable energies, EES market potential estimation for Germany by Fraunhofer, Storage of large amounts of energy in gas grids, EES market potential estimation for Europe by Siemens, EES market potential estimation by the IEA, Vehicle to grid concept, EES market potential in the future

**REFERENCES:**

1. andreasoberhofer@gmx.de
2. www.ecofys.com/com/publications
3. www.iec.ch

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## DE – 8.6. ELECTRICAL ENGINEERING MATERIALS

**Course Objectives:**

- To know the properties, characteristics of dielectric materials.
- To study the properties, characteristics of dielectric materials.
- To analyze the properties, characteristics of semiconductor materials.
- To discuss the different kind of materials for electric applications.
- To have a glance on the properties, characteristics of special materials.

**Course Outcomes:** At the end of the course the student will be able to:

- Evaluate insulating, conducting and magnetic materials used in electrical machines.
- Understand the properties of liquid, gaseous and solid insulating materials.
- Evaluate transformer oil by testing

**UNIT-I: DIELECTRIC MATERIALS**

Dielectric as Electric Field Medium,leakage currents, dielectric loss,dielectric strength, breakdown voltage,breakdown in solid dielectrics, flashover,liquid dielectrics,electric conductivity in solid,liquid and gaseous dielectrics, Ferromagnetic materials, properties of ferromagnetic materials in static fields,spontaneous, Polarization, Curie point, anti-ferromagnetic materials, piezoelectric materials, pyroelectric materials.

**UNIT-II: MAGNETIC MATERIALS**

Classification of magnetic materials, spontaneous magnetization in ferromagnetic materials,magnetic Anisotropy,Magnetostriction,diamagnetism, magnetically soft and hard materials,special purpose materials, feebly magnetic materials, Ferrites, cast and cermet permanent magnets,ageing of magnets.factors effecting permiablity and hystersis.

**UNIT-III: SEMICONDUCTOR MATERIALS**

Properties of semiconductors, Silicon wafers, integration techniques, Large and very large scale integration techniques (VLSI).

**UNIT-IV: MATERIALS FOR ELECTRICAL APPLICATIONS**

Materials used for Resistors, rheostats, heaters, transmission line structures, stranded conductors, bimetals fuses, soft and hard solders,electric contact materials, electric carbon materials, thermocouple materials.Solid Liquid and Gaseous insulating materials. Effect of moisture on insulation.

**UNIT-V: SPECIAL PURPOSE MATERIALS**

Refractory Materials, Structural Materilas, Radioactive Materials, Galvonization and Impregnation of materials, Processing of electronic materials, Insulating varnishes and coolants, Properties and applications of mineral oils, Testing of Transformer oil as per ISI.

**TEXT BOOKS:**

1. R K Rajput: A course in Electrical Engineering Materials, Laxmi Publications. 2009
2. T K BasaK: A course in Electrical Engineering Materials:, New Age Science Publications 2009

**REFRENCE:**

1. TTTI Madras: Electrical Engineering Materials
2. Adrianus J.Dekker: Electrical Engineering Materials , THM Publication