M. E. (Power Electronics & Drives)

2021 Regulations, Curriculum & Syllabi

Stay Ahead

BANNARI AMMAN INSTITUTE OF TECHNOLOGY

An Autonomous Institution Affiliated to Anna University - Chennai • Approved by AICTE • Accredited by NAAC with "A+" Grade

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BANNARI AMMAN INSTITUTE OF TECHNOLOGY
REGULATIONS 2021
(CHOICE BASED CREDIT SYSTEM)
Common to all M.E. / M.Tech. Degree Programmes

NOTE: *The regulations given hereunder are subject to amendments as may be decided by the Academic Council of the Institute from time to time. Any or all such amendments will be effective from such date and to such batches of students, including those already in the middle of the programme as may be decided by the Academic Council.*

1. ELIGIBILITY FOR ADMISSION

(i) Candidates seeking admission to the First Semester of M.E./M.Tech. degree programmes will be required to satisfy the eligibility criteria for admission thereto prescribed by the Directorate of Technical Education, Chennai and Anna University, Chennai.

(ii) Students admitted under 'Full-Time' should be available in the departments during the entire duration of working hours (from morning to evening on a full-time basis) for the curricular, co-curricular and extra-curricular activities.

The full-time students should not attend any other full-time programme(s) / course(s) or take up any full-time job / part-time job during working hours in any institution or company during the period of the full-time programme. Violation of the above rules will result in the cancellation of admission to the PG programme.

2. DURATION OF THE PROGRAMME

(i) **Minimum Duration:** Master of Engineering (M.E.) / Master of Technology (M.Tech.) extends over a period of two years. The two academic years will be divided into four semesters, with two semesters per year.

(ii) **Maximum Duration**: A candidate shall complete all the passing requirements of M.E./M.Tech. programmes within a maximum period of 4 years / 8 semesters, these periods being reckoned from the commencement of the first semester to which the candidate was first admitted, regardless of the break-of-study availed.

3. BRANCHES OF STUDY

Following M.E./M.Tech. programmes are offered by the institute

M.E. Programmes

1. Communication Systems
2. Computer Science and Engineering

3. Embedded Systems
4. Industrial Automation and Robotics
5. Industrial Safety Engineering
6. Power Electronics and Drives
7. Software Engineering
8. Structural Engineering

M. Tech. Programme

9. Biotechnology

4. STRUCTURE OF PROGRAMMES

(i) **Curriculum:** Every post- graduate programme will have a curriculum with syllabi consisting of theory and practical courses that include

Program Core Courses (PCC) include the core courses relevant to the chosen specialisation.

Program Elective Courses (PEC) include the elective courses relevant to the chosen specialisation.

Research Methodology and IPR Course to understand the importance and the process of creation of patents through research.

Employability Enhancement Courses (EEC) include project work, practical courses, internship, mini project and industrial/practical training.

Audit Courses (AC) expose the students to Disaster Management, Yoga, English for Research Paper Writing, Value education, Pedagogy Studies, Stress Management, and Personality Development through Life Enlightenment Skills. Registration for any of these courses is optional to students.

(ii) **Project Work:** Every student, individually, shall undertake Dissertation Phase I during the third semester and Dissertation Phase II during the fourth semester under the supervision of a qualified faculty. The project work can be undertaken in an industrial / research organisation or institute in consultation with the faculty guide and the Head of the Department. In the case of project work at an industrial / research organisation, the same shall be jointly supervised by a faculty guide and an expert from the organisation. The student shall be instructed to meet the supervisor periodically and attend the review committee meetings to evaluate the progress.

(iii) **Elective Courses: Five Elective** courses are offered to the students admitted in various disciplines as prescribed in the curriculum to widen their knowledge in their specialisation area.

(iv) **Online Courses:** A Student may be permitted to credit online courses with the approval of a Departmental Consultative Committee constituted by the Head of the Department, subject to a maximum of six credits. Such students may be exempted from attending the classes if such course(s) are offered in the semester. Summary of such online courses, taken by the students, along with the offering agency shall be presented to the Academic Council for information and further suggestions. However, the student needs to obtain certification from the agency offering the course to become eligible for writing or seeking exemption from the End Semester Examinations. In case of credits earned through online mode from the Institute / University, the credits may also be transferred directly after due approval from the Departmental Consultative Committee and the Controller of Examinations.

(v) **Industrial Training:** Every full-time student shall take up training in industry/research laboratories, under the supervision of a faculty guide during summer/winter vacation till the pre-final semester of the programme subject to the evaluation prescribed in Clause 15.

If industrial training/internship is not prescribed in the curriculum, the student may undergo industrial training/internship optionally, and the credits earned will be indicated in the Mark Sheet. If the student earns three credits in industrial training/internship, the student may drop one Program Elective in the III semester. In such cases, industrial training/internships need to be undergone continuously from one organisation only. However, if the number of credits earned is 1 or 2, these credits shall not be considered for the classification of the degree. The student is only allowed to undergo a maximum of 6 weeks of industrial training/internship during the entire duration of the study.

Duration of Training / Internship	**Credits**
2 Weeks	1
4 Weeks	2
6 Weeks	3

(vi) **Mini Project**: The students shall undertake a mini project individually in consultation with the respective faculty and Head of the Department, as specified in the curriculum. A student is expected to make a presentation about the mini-project during the final evaluation as given in Clause 15.

(vii) **Value Added / Certificate Courses:** Students can opt for any one of the value- added courses in II and III semesters, approved by the Academic Council. A separate certificate will be issued on successful completion of the course by the Controller of Examinations.

(viii) **Credit Assignment:** Each course is normally assigned a certain number of credits with 1 credit per lecture hour per week, 1 credit for 2 hours of practical per week, 1 credit for 1 hour of tutorial per week. The exact numbers of credits assigned to the different courses of various programmes are decided by the respective Board of Studies.

(ix) **Minimum Credits:** For the award of the degree, the student shall earn a minimum number of total credits as prescribed by the respective Board of Studies as given below:

S.No.	M.E./M. Tech. Programmes	Total Credits
1.	M.E. Communication Systems	68
2.	M.E. Computer Science and Engineering	68
3.	M.E. Embedded Systems	68
4.	M.E. Industrial Automation and Robotics	68
5.	M.E. Industrial Safety Engineering	68
6.	M.E. Power Electronics and Drives	68
7.	M.E. Software Engineering	68
8.	M.E. Structural Engineering	68
9.	M.Tech. Biotechnology	68

5. COURSE ENROLLMENT AND REGISTRATION

5.1 Each student, on admission, shall be assigned to a Faculty Advisor (vide Clause 7) who shall advise/counsel the student about the details of the academic programme and the choice of courses considering the student's academic background and career objectives.

5.2 Every student shall enrol for the courses of the succeeding semester in the current semester. However, the student shall confirm the enrolment by registering for the courses within the first five working days after the commencement of the semester concerned.

5.3 After registering for a course, a student shall attend the classes, satisfy the attendance requirements, earn Continuous Assessment marks and appear for the End Semester Examinations.

5.3.1 Each student on admission to the programme shall register for all the **courses prescribed in the curriculum** in the **first semester of study**.

5.3.2 The enrolment for all the courses of semester II will commence 10 working days prior to the last working day of the semester I. The student shall confirm the enrolment by registering for the courses within the first five working days after the commencement of semester II.

5.3.3 If a student wishes, the student may drop or add courses (vide Clause 5.5) within **five** working days after the commencement of the semester concerned and complete the registration process duly authorised by the PG coordinator of the programme. In this case, if a student fails in a course, he/she may be permitted to register for the course in the subsequent semester or when it is offered.

5.3.4 A student who has passed all the courses prescribed in the curriculum for the award of the degree shall not be permitted to re-enrol to improve the student's marks in a course or the aggregate marks / CGPA.

5.4 Minimum Credits to Register for Project work

The Project work for M.E./M.Tech. consists of dissertation phase I and dissertation phase II. Dissertation phase I is to be undertaken during the III semester, and dissertation phase II, which is a continuation of phase I, is to be undertaken during the IV semester. Minimum 24 credits are required to be earned to enrol on dissertation phase I.

If a student fails to earn the requisite minimum credits, the student cannot enrol for dissertation phase I. In such a case, the student can enrol for the project work in a subsequent semester after earning the minimum credits specified.

5.5 Flexibility to Add or Drop courses

5.5.1 A student has to earn the total number of credits specified in the curriculum of the respective programme of study in order to be eligible to obtain the degree. However, if a student wishes, the student is permitted to earn more than the total number of credits prescribed in the curriculum of the student's programme by opting for additional courses.

5.5.2 From the II to final semesters, the student has the option to register for additional courses or drop existing courses. The total number of credits that a student can add or drop is limited to 6, subject to a maximum of 2 courses. In such cases, the attendance requirement as stated in Clause 6 is mandatory.

The courses that a student registers in a particular semester may include:

i. Courses of the current semester and

ii. Courses dropped in the lower semesters.

The maximum number of credits that can be registered in a semester is 36. However, this does not include the number of Re-appearance (RA) and Withdrawal (W) courses registered by the student for the appearance of Examination.

5.6 Reappearance Registration

5.6.1 If a student fails in a theory course, the student shall do reappearance registration for that course in the subsequent semester or when it is offered next.

5.6.2 On registration, a student may attend the classes for the reappearance registration courses if the student wishes. However, the attendance requirement (vide Clause 6) is not compulsory for such courses.

5.6.3 The student who fails in any practical/mini project or any other EEC courses shall register for the same in the subsequent semester or when offered next and **repeat** the course. In this case, the student shall attend the classes, satisfy the attendance requirements (vide Clause 6) and earn continuous assessment marks.

5.6.4 The student who fails in dissertation phase I / II shall register for the same in the subsequent semester or when offered next and **repeat** the course. In this case, the student shall attend the classes, satisfy the attendance requirements (vide Clause 6), earn continuous assessment marks and appear for the end semester examinations. Reappearance registration is not available for such courses.

5.6.5 If a student is prevented from writing the end semester examination of a course due to lack of attendance, the student has to register for that course again, when offered next, attend the classes and fulfil the attendance requirements as per Clause 6.

6. REQUIREMENTS FOR APPEARING FOR THE END SEMESTER EXAMINATION OF A COURSE

A student who has fulfilled the following conditions (vide clause 6.1 and 6.2) shall be deemed to have satisfied the attendance requirements for appearing for the End Semester Examination of a particular course.

Each semester shall normally consist of 75 working days or 540 periods of each 50 minutes duration for the full-time mode of study.

6.1 Ideally, every student is expected to attend all the periods and earn 100% attendance. However, a student shall secure not less than 80% attendance course wise taking into account the number of periods required for that course as specified in the curriculum.

6.2 If a student secures attendance between 70% and 79% in any course in the current semester due to medical reasons (prolonged hospitalisation/accident / specific illness) or participation in Institution/University/State/National/International level extra and co-curricular activities, with prior permission from the Head of the Department, shall be permitted to appear for the current semester examinations subject to the condition that the student shall submit the medical certificate/participation certificate attested by the Head of the Department. Such certificates shall be forwarded to the Controller of Examinations for verification and permission to attend the examinations.

6.3 A student shall normally be permitted to appear for the end semester examination of a course if the student has satisfied the attendance requirements (vide Clause 6.1-6.2) and has registered for the examination in those courses of that semester by paying the prescribed fee.

6.4 A student who does not satisfy clauses 6.1 and 6.2 and secures less than 70% attendance in a course will not be permitted to write the end semester examination. The student has to register and repeat this course in the subsequent semester or when it is offered next (vide clause 5.6.4).

6.5 A student who has already appeared for a course in a semester and passed the examination is not entitled to reappear in the same course to improve grades/marks.

7. FACULTY ADVISOR

To help students plan their courses of study and for general advice on the academic programme, the Head of the Department of the students will attach a certain number of students to a teacher of the department, who shall function as a faculty advisor for those students throughout their period of study. The faculty advisor shall advise the students in registration and reappearance (Arrear) registration of courses, authorise the process, monitor their attendance and progress and counsel them periodically. If necessary, the faculty advisor may also discuss with or inform the parents about the progress/performance of the students concerned.

The responsibilities of the faculty advisor shall be:

i. To inform the students about the various facilities and activities available to enhance the student's curricular and co-curricular activities.

ii. To guide student enrolment and registration of the courses

iii. To authorise the final registration of the courses at the beginning of each semester.

iv. To monitor the academic and general performance of the students, including attendance, and to counsel them accordingly.

v. To collect and maintain the academic and co-curricular records of the students

8. COMMITTEES

8.1 Class Committee Meeting

i. For all the courses taught, prescribed in the curriculum, a class committee meeting shall be convened twice a semester, comprising faculty members handling all the courses and two student representatives from the class.

ii. One of the faculty members (not handling any courses to that class), nominated by the Head of the Department, shall coordinate the activities of this Committee. During these meetings, the student members shall meaningfully interact and express their opinions and suggestions of all students to improve the effectiveness of the teaching-learning process. It is the responsibility of the student representatives to convey the proceedings of these meetings to all other students.

9. ASSESSMENT AND PASSING REQUIREMENTS

9.1 Assessment

The assessment will comprise continuous assessment and end semester examination, carrying marks as specified in the scheme (Clause 15). All assessments will be done on absolute marks basis. However, to report the performance of a student, letter grades and grade points will be awarded as per Clause 9.4.

9.2 End Semester Examinations

End semester examinations will normally be conducted as per the timetable circulated by the CoE's Office. A student will be permitted to appear for the end semester examination of a semester only if he/she completes the study of that semester satisfying the requirements given in Clause 5 and 6, and registers simultaneously for the examinations of the highest semester eligible and the courses, pertaining to that semester, that needs reappearance.

9.3 Employability Enhancement Courses

Every candidate shall submit reports on industrial training / mini-project, dissertation phase I and dissertation phase II on dates announced by the institute/department through the faculty guide to the head of the department. If a candidate fails to submit the reports of any of these courses not later than the specified date, he/she is deemed to have failed in it. The reports /papers shall be orally presented by the student before a team of experts consisting of an internal examiner, usually the supervisor, and an external examiner, appointed by the Controller of the Examination.

A candidate is permitted to register for dissertation phase II only after passing dissertation phase I. A candidate who fails in industrial training / mini-project, dissertation phase I or dissertation phase II shall register for redoing the same at the beginning of a subsequent semester.

9.4 Letter Grade and Grade Point

The letter grade and the grade point are awarded based on the percentage of total marks secured by a candidate in an individual course as detailed below:

Letter Grade	Grade Points
O (Outstanding)	10
A + (Excellent)	9
A (Very Good)	8
B + (Good)	7
B (Above average)	6
C (Satisfactory)	5
RA (Reappearance Registration)	0
I (Incomplete)	0
W (Withdrawal)	0
AB (Absent)	0
SA(Shortage of Attendance)	0

'RA' - Reappearance registration is required for that particular course

'I' - Continuous evaluation is required for that particular course in the subsequent examinations.

After completion of the evaluation process, Semester Grade Point Average (SGPA) and Cumulative Grade Point Average is calculated using the formula:

$$SGPA/CGPA = \frac{\sum_{1}^{n} C_i * g_i}{\sum_{1}^{n} C_i}$$

where

C_i Credit allotted to the course.

g_i Grade Point secured corresponding to the course.

n number of courses successfully cleared during the particular semester in the case of SGPA and all the semesters, under consideration, in the case CGPA.

9.5 A student can apply for revaluation of his/her semester examination answer paper in a theory course, within 3 working days from the declaration of results, along with prescribed application to the Controller of Examinations through the Head of Department. Revaluation is not permitted for laboratory courses, industrial training, and project works.

9.6 Passing a Course

A candidate who secures Grade Point 6 or more in any course of study will be declared to have passed that course, provided he/she secures a minimum of 50% of the total mark in the end semester examination of that course.

If a student fails to secure a pass in theory courses and laboratory courses in the current semester examination, he/she is allowed to write arrear examinations for the next three consecutive semesters, and their internal marks shall be carried over for the above mentioned period of three consecutive semesters.

In case if he/she has not completed all the courses of the semester I at the end of semester IV, he/she shall redo the semester I courses along with regular students. The same procedure shall be followed for the subsequent semesters of II, III and IV, subject to the maximum permissible period for this programme.

9.7 If a candidate fails in the end semester examinations of Phase I, he/she has to resubmit the project report within 30 days from the date of declaration of the results. If he/she fails in the end semester examination of Phase II of M.E. / M.Tech., he/she shall resubmit the project report within 60 days from the date of declaration of the results. The resubmission of the project report and the subsequent viva voce examination will be considered as reappearance with payment of the exam fee. If a student fails to resubmit the project report within the stipulated period and fails in the subsequent viva-voce examination, the student shall register for the course again in the subsequent semester.

10. REJOINING THE PROGRAMME

A candidate who has not completed the study of any of the semesters as per Clause 6 or who is allowed to rejoin the programme after the period of discontinuance or who on his/her own request is permitted to repeat the study of any semester (break of study), may join the semester which he/she is eligible or permitted to join, only at the time of its normal commencement for a regular batch of candidates and after obtaining the approval from the Director of Technical Education and Anna University, Chennai. In such a case, earlier continuous assessment in the repeated courses will be disregarded. However, no candidate will be allowed to enrol in more than one semester at any point of time.

11. QUALIFYING FOR THE AWARD OF THE DEGREE

A candidate will be declared to have qualified for the award of the M.E. / M.Tech. Degree provided:

i. He/she has completed the course requirements and has passed all the prescribed courses of study of the respective programme listed in Clause 3 within the duration specified in Clause 2.

ii. No disciplinary action is pending against the candidate.

12. CLASSIFICATION OF THE DEGREE AWARDED

12.1 First Class with Distinction:

A student who satisfies the following conditions shall be declared to have passed the examination in First class with Distinction:

- Should have passed the examination in all the courses of all the four semesters in the student's First Appearance within two years (Three years in case of authorised break of study of one year (if availed)). Withdrawal from examination (vide Clause 13) will not be considered as an appearance.
- Should have secured a CGPA of not less than 8.50.
- Should NOT have been prevented from writing end Semester examination due to lack of attendance in any of the courses.

12.2 First Class:

A student who satisfies the following conditions shall be declared to have passed the examination in first-class:

- Should have passed the examination in all the courses of all four semesters within three years, including one year of authorised break of study (if availed) or prevention from writing the End Semester Examination due to lack of attendance (if applicable).
- Should have secured a CGPA of not less than 6.50

12.3 Second Class:

All other students (not covered in clauses 12.1 and 12.2) who qualify for the award of the degree shall be declared to have passed the examination in the second class.

12.4 A student who is absent in the End Semester Examination in a course/project work after having registered for the same shall be considered to have appeared in that examination (except approved withdrawal from end semester examinations as per clause 13) for the purpose of classification.

13. WITHDRAWAL FROM EXAMINATION

13.1 A student may, for valid reasons, be granted permission by the Head of the Department to withdraw from appearing in the examination in any course(s) only once during the entire duration of the degree programme.

13.2 Withdrawal application shall be valid only if the student is eligible to write the examination as per Clause 6 and if such withdrawal request is made prior to the submission of marks of the continuous assessment of the course(s) with the recommendations from the Head of the Department.

13.3 If a student withdraws a course or courses from writing end semester examinations, he/she shall register the same in the subsequent semester and write the end semester examination(s)

13.4 Withdrawal shall not be considered as an appearance for deciding the eligibility of a candidate for first class with distinction or first class.

13.5 Withdrawal is permitted for the end semester examinations in the final semester only if the period of study the student concerned does not exceed 3 years for M.E. / M.Tech. as per clauses 12.1 and 12.2.

14. AUTHORISED BREAK OF STUDY FROM A PROGRAMME

14.1 A student is permitted to go on a break of study for a fixed period of one year as a single break in the entire course of study.

14.2 A student who would like to avail the break of study, on account of short term employment / medical treatment / personal reasons) shall apply to the Head of the Institution through the concerned Head of the Department (application available with the Controller of Examinations), in any case, not later than the last date for registering for the semester.

14.3 The students permitted to re-join the programme after a break of study/prevention

due to lack of attendance shall be governed by the curriculum and regulations in force at the time of re-joining. A committee constituted by the Head of the Institution shall prescribe additional/equivalent courses, if any, from the regulation in force to bridge the requirement between the curriculum in force and the old curriculum.

14.4 The total period for completion of the programme reckoned from the commencement of the first semester to which the student is admitted shall not exceed the maximum period specified in Clause 2, irrespective of the period of break of study in order that he/ she may be eligible, for the award of the degree (vide Clause 11 and 12).

14.5 In case of any valid reasons for the extension of break-of-study, such extended break-of-study may be granted by the Head of the Institution for a period not more than one year in addition to the earlier authorised break of study. Such extended break-of-study shall be counted for the purpose of classification of degree (vide clause 12).

14.6 If a student does not report back to the institute, even after the extended break of study, the name of the student shall be deleted permanently from the college enrolment. Such candidates are not entitled to seek readmission under any circumstances.

15. SCHEME OF ASSESSMENT

I	**THEORY COURSES**	**Marks**
	Continuous Assessment	**50**
	Distribution of marks for Continuous Assessment:	
	Periodical Test I (15)	
	Periodical Test II (15)	
	Term Paper Report (10) & Presentation (10)	
	End Semester Examination	**50**
	Total Marks	**100**
II	**THEORY COURSES WITH LAB COMPONENT**	**Marks**
	Continuous Assessment	**50**
	Distribution of marks for Continuous Assessment:	
	Periodical Test I (15)	
	Periodical Test II (15)	
	Lab Examination (10)	
	Viva-voce (10)	
	End Semester Examination (QP pattern as per (I))	**50**
	Total Marks	**100**
III	**PRACTICAL COURSES**	**Marks**
	Continuous Assessment	**100**
	Distribution of marks for Continuous Assessment:	
	<u>Conduct of Experiment</u>	
	i. Preparation (10)	
	ii. Experiment and Analysis of Results (20)	
	iii. Record (5)	
	Self-Learning Experiment (15)	
	Test - Cycle I (15)	
	Test - Cycle II (15)	
	Final Viva-voce (20)	
	Total Marks	**100**
IV	**DISSERTATION PHASE I**	**Marks**
	Continuous Assessment	**50**
	Distribution of marks for Continuous Assessment:	
	<u>Review I</u>	
	Identification of topic and Justification (5)	
	Literature Survey (5)	
	<u>Review II</u>	
	Work plan & Approach (10)	
	Progress, Results and Discussion (10)	
	<u>Review III</u>	
	Conclusion (10)	
	Implementation & Applications (10)	

	End Semester Examination	
	Presentation (20)	**50**
	Report (10)	
	Viva Voce (20)	
	Total Marks	**100**
V	**DISSERTATION PHASE II**	**Marks**
	Continuous Assessment	**50**
	Distribution of marks for Continuous Assessment:	
	<u>Review I</u>	
	Work plan & Approach (10)	
	<u>Review II</u>	
	Progress (10)	
	Results and Discussion (10)	
	<u>Review II</u>	
	Conclusion (10)	
	Implementation & Applications *(10)*	
	End Semester Examination	
	Presentation (20)	**50**
	Report (10)	
	Viva Voce (20)	
	Total Marks	**100**
VI	**MINI PROJECT**	**Marks**
	Continuous Assessment	**100**
	Distribution of marks for Continuous Assessment:	
	Review I	**25**
	Review II	**25**
	Presentation & Viva voce	**50**
	Total Marks	**100**
VII	**INDUSTRIAL TRAINING / INTERNSHIP**	**Marks**
	Continuous Assessment	**100**
	Presentation	**30**
	Viva-voce	**30**
	Case study / Report	**40**
	Total Marks	**100**
VIII	**VALUE ADDED COURSES / CERTIFICATE COURSES (Continuous Assessment Only)**	**Marks**
	Test I	50
	Test II	50
	Grades: Excellent (>80) / Good (61≤Marks ≤ 80) / Satisfactory (50≤Marks ≤ 60))	

Optional Test: *A student becomes eligible to appear for the one optional test conducted after the Periodical Test II, only under the following circumstances, if absent for Test I or Test II or both, on account of (i) medical reasons (hospitalisation / accident / specific illness) (ii) participation in the college/university/state / national/international level Sports events with prior permission from the Head of the Institution and (iii) on satisfying the conditions (i) or (ii), the student should have registered for the Optional Test, through the concerned faculty member who handles the course or through the respective Head of the Department, submitted to the Controller of Examinations. Such Optional Tests are not conducted for the courses under the categories III, IV, V, VI, VII and VIII listed above.*

16. DISCIPLINE

A student is expected to follow the rules and regulations laid down by the Institute and the affiliating University, as published from time to time. Any violations, if any, shall be treated as per the procedures stated thereof.

If a student indulges in malpractice in any of the end semester / continuous assessments, he/she shall be liable for punitive action as prescribed by the institution / university from time to time.

M.E. POWER ELECTRONICS AND DRIVES

Minimum credits to be earned: 68

First Semester								
Code No.	**Course**	**Objectives & Outcomes**		**L**	**T**	**P**	**C**	**Hours/ Week**
		PEOs	**POs**					
21PE11	Research Methodology and IPR	III	e,f	2	0	0	2	2
21PE12	Design and Analysis of Power Converters	I,II	a,c,d	3	0	0	3	3
21PE13	Modeling and Analysis of Electrical Machines	I,II	a,b,d	3	0	0	3	3
21PE14	System Theory	I	a,b	3	1	0	4	4
	Program Elective I	-	-	3	0	0	3	3
21PE16	Power Electronics Laboratory	I,II,III	b,c,d,e,f	0	0	4	2	4
21PE17	Modeling of Electrical Machines Laboratory	I,II,III	a,b,c,d,e,f	0	0	4	2	4
	Audit course 1[1]			2	0	0	-	2
			Total	**16**	**1**	**8**	**19**	**25**

Second Semester								
Code No.	**Course**	**Objectives & Outcomes**		**L**	**T**	**P**	**C**	**Hours/ Week**
		PEOs	**POs**					
21PE21	Solid State Drives and Control	I,II,III	a,b,c,e,f	3	0	0	3	3
21PE22	Design and Analysis of Advanced Power Converters	I,II	a,b,c	3	0	0	3	3
21PE23	Switched Mode and Resonant Converters	I,II	a,b,c,d	3	0	0	3	3
	Program Elective II	-	-	3	0	0	3	3
	Program Elective III	-	-	3	0	0	3	3
21PE26	Electrical DrivesLaboratory	I,II,III	b,c,d,e,f	0	0	4	2	4
21PE27	Mini project	I,II,III	a,b,c,d,e,f	0	0	4	2	4
	Audit course II[1]	-	-	2	0	0	-	2
			Total	**17**	**0**	**8**	**19**	**25**

[1]Audit Course is optional

Third Semester								
Code No.	**Course**	**Objectives & Outcomes**		**L**	**T**	**P**	**C**	**Hours/ Week**
		PEOs	**POs**					
	Program Elective IV	-	-	3	0	0	3	3
	Program Elective V	-	-	3	0	0	3	3
21PE33	Dissertation Phase I	I,II,III	a,b,c,d,e,f	0	0	20	10	20
			Total	**6**	**0**	**20**	**16**	**26**
Fourth Semester								
Code No.	**Course**	**Objectives & Outcomes**		**L**	**T**	**P**	**C**	**Hours/ Week**
		PEOs	**POs**					
21PE41	Dissertation Phase II	I,II,III	a,b,c,d,e,f	0	0	28	14	28
			Total	**0**	**0**	**28**	**14**	**28**
List of Core Electives								
Code No.	**Course**	**Objectives & Outcomes**		**L**	**T**	**P**	**C**	**Hours/ Week**
		PEOs	**POs**					
21PE51	Power Quality Monitoring and Mitigation Techniques	I,II	a,b,c	3	0	0	3	3
21PE52	Special Electrical Machines	I,II	a,b,c	3	0	0	3	3
21PE53	Power Converters for Renewable Energy Systems	I,II	a,b,c	3	0	0	3	3
21PE54	Electric Vehicles and Energy Storage Systems	I,II	a,b,c	3	0	0	3	3
21PE55	Control and Integration of Renewable Energy Sources	I,II	a,b,c	3	0	0	3	3
21PE56	Battery Management systems	I,II	a,b,c	3	0	0	3	3
21PE57	Harmonics Filter Design	I	a,b	3	0	0	3	3
21PE58	Electromagnetic Interference and Compatibility	I,II	a,b,c	3	0	0	3	3
21PE59	Modern Controllers for Industrial Drives	I,II	a,b,d	3	0	0	3	3
21PE60	Distributed Generation Systems	I,II	a,b,c	3	0	0	3	3
21PE61	Smart Grid Technologies	I,II	a,b,c	3	0	0	3	3
21PE62	HVDC Systems	I,II	a,b,c	3	0	0	3	3
21PE63	Automotive Electronics	I,II,III	a,c,e,f	3	0	0	3	3
21PE64	Optimization Techniques	I,II	a,b,c,d	3	0	0	3	3
21PE65	Electrical Energy Conservation and Management	I,II,III	a,b,c,e	3	0	0	3	3
21PE66	DSP Based System Design	I,II,III	b,c,e,f	3	0	0	3	3

List of Audit courses I & II								
Code No.	**Course**	**Objectives & Outcomes**		**L**	**T**	**P**	**C**	**Hours/ Week**
		PEOs	**POs**					
21XE01	English for Research Paper Writing	II,III	e,f	2	0	0	-	2
21XE02	Cost Management of Engineering Projects	I,III	c,e,f	2	0	0	-	2
21XE03	Stress Management	II,III	c,e,f	2	0	0	-	2
21XE04	Disaster Management	III	e,f	2	0	0	-	2
21XE05	Value Education	II,III	e,f	2	0	0	-	2
21XE06	Pedagogy Studies	I,III	a,b,e,f	2	0	0	-	2
21XE07	Business Analytics	II,III	e,f	2	0	0	-	2

21PE11 RESEARCH METHODOLOGY AND IPR 2 0 0 2

Course Objectives

- To enable the student to understand the research problem formulation.
- To apply the Patents, Designs, Trade and Copyright.
- To understand that IPR protection provides an incentive to inventors for further research work and investment in R & D.

Programme Outcomes (POs)

e. Attain proficiency in Communication and to work in multidisciplinary team as an individual or leader in Power Electronics and Drives industries.
f. Engage in lifelong learning, plan and conduct a systematic study on significant research with effective utilization of resources.

Course Outcomes (COs)

1. Analyze the research problem formulation.
2. Analyze research related information.
3. Apply the IPR in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property
4. Right to be promoted among students in general & engineering in particular.
5. Analyze IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

UNIT I **6 Hours**
MEANING OF RESEARCH PROBLEM
Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations.

UNIT II **6 Hours**
EFFECTIVE LITERATURE
Effective literature studies approaches, analysis Plagiarism, and Research ethics.

UNIT III **6 Hours**
EFFECTIVE TECHNICAL WRITING
Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

UNIT IV **6 Hours**
NATURE OF INTELLECTUAL PROPERTY
Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

UNIT V **6 Hours**

PATENT RIGHTS

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

FOR FURTHER READING

New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

Total: 30 Hours

Reference(s)

1. Stuart Melville and Wayne Goddard, Research methodology: an introduction for science & engineering students,1996.
2. Wayne Goddard and Stuart Melville, Research Methodology: An Introduction
3. Ranjit Kumar, 2nd Edition, Research Methodology: A Step by Step Guide for beginners
4. Halbert, Resisting Intellectual Property, Taylor & Francis Ltd , 2007.
5. Mayall , Industrial Design, McGraw Hill, 1992.

21PE12 DESIGN AND ANALYSIS OF POWER CONVERTERS

3 0 0 3

Course Objectives

- Interpret the switching and steady state characteristics of power switches, which will enable them to analyze the operation of controlled rectifiers.
- Apply the basic concepts of dc-dc converters and ac-ac converters to design the circuits in various applications.
- Design and analyze the operating modes and modulating techniques of voltage source, current source, Z source, resonant and multilevel inverters.

Programme Outcomes (POs)

a. Apply the core knowledge to identify, formulate, and solve problems in Power Electronics and Drives systems.
c. Design power electronic circuits for industrial and commercial applications with due consideration on public health, safety and environmental constraints with sustainability and ethical responsibility.
d. Select and apply appropriate tools for modeling, simulation and analysis of power electronics circuits for renewable energy applications.

Course Outcomes (COs)

1. Analyze the operational characteristics of single, three phase half controlled and fully controlled converters.
2. Design DC-DC converter topologies using volt-seconds balance method for power conversion applications.
3. Analyze the performance characteristics of ac-ac converters for variable frequency applications.
4. Analyze the performance parameters of inverters using different PWM techniques.
5. Analyze the equivalent circuit and control techniques of Z source inverter and Resonant Inverters.

UNIT I **9 Hours**

AC-DC CONVERTER

Construction, operation, types, switching and steady state characteristics of Power Diodes, SCRs,IGBTs and MOSFETs- Design of snubber circuits - Commutation - Opto coupler and driver circuits- Design of heat sinks.-Single phase and Three phase half controlled and fully controlled converters -Dual converters - Effect of source impedance and overlap.

UNIT II **9 Hours**

DC-DC CONVERTERS

Principles of step-down and step-up converters - Analysis and design of Buck-Boost, CUK, LUO and SEPIC converters - Control methods of DC to DC converters- duty ratio control. Principles of volt-seconds balance in inductor for analysis of DC-DC converter topologies. Current ripple and voltage ripple calculations.

UNIT III **9 Hours**

AC - AC CONVERTERS

Single phase and three phase AC voltage controllers - Single phase and three phase Cyclo converters - Analysis of performance parameters: Output Voltage, input current and PWM schemes - Concept of Matrix Converters - Applications.

UNIT IV **9 Hours**

INVERTERS

Performance analysis of voltage source inverter- PWM Techniques-Analysis of single pulse, multiple pulse modulations and sinusoidal pulse modulation - various harmonic elimination techniques. Voltage source inverters, Current source inverters, series inverters and parallel Inverters - Basics of Multilevel Inverters.

UNIT V **9 Hours**

Z-SOURCE AND RESONANT INVERTERS

Principle of operation of Z- source inverter- Shoot through zero State-Equivalent circuit-PWM methods for Z-Source inverters. Series and parallel resonant inverters - voltage control of resonant inverters - Class E resonant inverter - Resonant DC - link inverters.

FOR FURTHER READING

SVPWM schemes for AC voltage controllers and Matrix converter-PWM inverters, Comparison of PWM, AVI and CSI, Multilevel matrix converters

Total: 45 Hours

Reference(s)

1. M.H. Rashid, Power Electronics: Circuits, Devices and Application, Pearson, India; 2017.
2. Ned Mohan, Tore M. Undeland and William P.Robbins, Power Electronics: Converters, Applications and Design,New Jersey, John Wiley and Sons, 2007.
3. Hua Bai, Chris Mi, Transients of Modern Power Electronics, John Wiley & Sons, 2011.
4. M.H. Rashid, Hand Book of Power Electronics: Circuits, Devices and Application,Pearson ,India , 2013.
5. Marty Brown, Power sources and supplies Newnes, Elsevier, Second edition,2010.

21PE13 MODELING AND ANALYSIS OF ELECTRICAL MACHINES

3 0 0 3

Course Objectives

- Interpret steady state and dynamic state operation of electrical machines which will enhance them to analyze the characteristics.
- Develop the mathematical models for electrical machines which will enable them to model different rating of electrical machines.
- Recognize the theory of transformation of three phase variables to two phase Variables and apply for the various electrical machines.

Programme Outcomes (POs)

a. Apply the core knowledge to identify, formulate, and solve problems in Power Electronics and Drives systems.
b. Apply knowledge in mathematics, science, electric and electronic circuits to develop and analyze mathematical models for power electronic converters and controllers.
d. Select and apply appropriate tools for modeling, simulation and analysis of power electronics circuits for renewable energy applications.

Course Outcomes (COs)

1. Analyze the steady state and dynamic characteristics of DC machines and compute the equation for airgap mmf.
2. Analyze the stationary circuit variables in arbitrary reference frame and find the dynamic equations of a generalized machine.
3. Apply the reference frame theory to three phase symmetrical induction machine and compute the voltage and torque equation.
4. Apply the reference frame theory and generalized theory to three phase synchronous machine.
5. Analyze the performance of Permanent magnet DC motor and Switched reluctance motor with modeling equations.

UNIT I **9 Hours**

DC MACHINES

Elementary DC machine and analysis of steady state operation - Calculation of air gap mmf of a DC machine -Voltage and torque equations - dynamic characteristics of permanent magnet and shunt DC motors -Magnetic leakage in rotating machines.

UNIT II **9 Hours**

REFERENCE FRAME THEORY

Historical background - Phase transformation and commutator transformation - Stationary circuit variables transformed to the arbitrary Reference frame treating R, L, C elements separately-variables observed from several frames of reference. Formulation of dynamic equations of a generalized machine in arbitrary reference frame.

UNIT III **9 Hours**

INDUCTION MACHINE MODELING

Static and rotating Reference(s): frames, transformation relationships - Application of Reference frame theory to three phase symmetrical induction machine -DQ flux linkages model derivation Direct and quadrature axis model in arbitrarily rotating Reference frame - Voltage and torque equations.

UNIT IV **9 Hours**

SYNCHRONOUS MACHINE MODELING

Application of reference frame theory to three phase synchronous machine-dynamic model analysis-Park's equation - Voltage and torque equations - Generalized theory of rotating electrical machine and Kron's primitive machine. Analysis of steady state operation.

UNIT V **9 Hours**

PMDC AND SRM MODELING

Modeling of PM brushless DC Motor -Commutation torque ripple-phase advancing -Normalized system equations-SRM Modeling - Electromechanical energy conversion and Torque Production Linear magnetic circuit.

FOR FURTHER READING

Linearization of machine equations, Small displacement stability: Eigen values, Eigen values of typical induction machine and synchronous machine, Transfer function formulation.

Total: 45 Hours

Reference(s)

1. Harles Kingsley Jr., A.E. Fitzgerald and Stephen D.Umans, Electric Machinery, New York, McGraw- Hil Higher Education, 2015.
2. Paul C. Krause, Oleg Wasynczuk and Scott D. Sudhoff, Analysis of Electric Machinery and Drive Systems, New Jersey, Wiley Student Edition, 2013.
3. R. Krishnan, Electric Motor & Drives: Modeling, Analysis and Control, New Delhi,Prentice Hall of India, 2015.
4. J. R. Hendershot, James R. Hendershot, Timothy John Eastham Miller, Design of Brushless Permanent-magnet Machines, Motor Design Books, 2010.
5. K.T Chau, Electric Vehicle Machines and Drives: Design, Analysis and Application ,John Wiley & Sons, 2015.

21PE14 SYSTEM THEORY 3 1 0 4

Course Objectives

- Interpret the modeling of systems in state variable form and solve linear and non-linear state equations.
- Analyse the properties of state equations and solve nonlinear systems using describing function and phase plane analysis.
- Analyse the stability of the system, develop the modal concepts and design the feedback controllers and estimators.

Programme Outcomes (POs)

a. Apply the core knowledge to identify, formulate, and solve problems in Power Electronics and Drives systems.
b. Apply knowledge in mathematics, science, electric and electronic circuits to develop and analyze mathematical models for power electronic converters and controllers.

Course Outcomes (COs)

1. Analyze the State equation and construct a state diagram for physical and electrical system.
2. Analyze the Nonlinear and Linear Time Varying State equations and evaluate matrix exponential using Eigen values and Eigenvectors.
3. Apply suitable method for Linearization of nonlinear systems and analyse its describing function.
4. Analyze the Stability of Linear Continuous time invariant systems using Lyapunov, Krasovskii and Variable Gradient Method.
5. Analyze the effects of Controllability and Observability in Continuous Time Invariant systems and design the State Feedback Controllers and Observers.

UNIT I **9 Hours**

STATE VARIABLE REPRESENTATION

Introduction -Concept of State-State equation for Dynamic Systems - Time invariance and linearity - Non uniqueness of state model-State Diagrams- Physical System and State Assignment. Transformations- Phase variable form - Canonical form.

UNIT II **9 Hours**

SOLUTION OF STATE EQUATIONS

Existence and uniqueness of solutions to Continuous-time state equations-Solution of Nonlinear and Linear Time Varying State equations-Evaluation of matrix exponential-System modes- Role of Eigen values and Eigenvectors. State transition matrix- Properties and methods of evaluation. Simulation of state equation using MATLAB Simulink program. Controllability and Observability-Stabilizability and Detectability - Reachability of linear systems.

UNIT III **9 Hours**

ANALYSIS OF NON LINEAR SYSTEMS

Classification and types of non-linearity.Methods of analysis. Linearization based on Taylors series expansion. Jacobian Linearization. Phase trajectory and its construction. Phase-plane analysis of linear and non-linear systems. Existence of limit cycles. Describing function of typical non-linearities.

UNIT IV **9 Hours**

STABILITY

Introduction-Equilibrium Points-Stability in the sense of Lyapunov-BIBO Stability-Stability of LTI Systems-Equilibrium Stability of Nonlinear Continuous Time Autonomous Systems-The Direct Method of Lyapunov and the Linear Continuous-Time Autonomous Systems-Finding Lyapunov Functions for Nonlinear Continuous Time Autonomous Systems-Krasovskii and Variable-Gradient Method. Popovs result and frequency domain criterion, extension to Popov result and circle criterion Input to state stability and relative stability.

UNIT V **9 Hours**

MODAL CONTROL

Introduction-Controllable and Observable Companion Forms-SISO and MIMO Systems-The Effect of State Feedback on Controllability and Observability-Pole Placement by State Feedback for both SISO and MIMO Systems-Full Order and Reduced Order Observers. Kalman Decomposition. State feedback with integral control, asymptotic tracking and regulation, optimal control concept, solution of linear quadratic regulator.

FOR FURTHER READING

Sliding mode Controller, LQR controller, Tuning of PID, Sliding mode Observer.

Total: 60 Hours

Reference(s)

1. M. Gopal, Modern Control System Theory, New Age International Private Limited, January 2014.
2. K. Ogatta, Modern Control Engineering, Prentice Hall of India, 2010.
3. Harry Kwatny, Bor-Chin Chang, Introduction to Control System Design, Cognella, Incorporated, 2017.
4. Constantine H. Houpis, Stuart N. Sheldon, Linear Control System Analysis and Design with MATLAB, Taylor Francis, sixth edition, 2013.
5. Varmah K R, Modern Control Theory, CBS Publishers and Distributors, 2017.

21PE16 POWER ELECTRONICS LABORATORY 0 0 4 2

Course Objectives

- Understand the various power converter topologies for power quality improvement
- Analyse the duty cycle variations of buck-boost regulators for lighting applications
- Design and harmonic analysis of multilevel inverter technologies for adjustable speed drives.
- To Design a DC-to-DC converter for EV applications.

Programme Outcomes (POs)

b. Apply knowledge in mathematics, science, electric and electronic circuits to develop and analyze mathematical models for power electronic converters and controllers.
c. Design power electronic circuits for industrial and commercial applications with due consideration on public health, safety and environmental constraints with sustainability and ethical responsibility.
d. Select and apply appropriate tools for modeling, simulation and analysis of power electronics circuits for renewable energy applications.
e. Attain proficiency in Communication and to work in multidisciplinary team as an individual or leader in Power Electronics and Drives industries.
f. Engage in lifelong learning, plan and conduct a systematic study on significant research with effective utilization of resources.

Course Outcomes (COs)

1. Analyse the power quality issues in electrical system using power quality analyser
2. Design a buck /boost converter and analyse the output voltage for various duty cycles used in lighting applications.
3. Design a dc-dc converter for Electric vehicle applications and analyse its output parameters.
4. Analyse the harmonics in the output voltage of three phase AC voltage controller using SCR and TRIAC.
5. Analyse the harmonic distortions in the Voltage source inverters with various PWM techniques for variable frequency drives.

1 **4 Hours**

EXPERIMENT 1

Simulation and verification of Three phase Semi converter with RL and RLE loads

2 **4 Hours**

EXPERIMENT 2

Simulation and Experimental verification of three phase fully controlled converter with R, RL, and RLE loads using LC filter.

3 **4 Hours**

EXPERIMENT 3

Simulation and Experimental verification of Three-phase AC voltage Regulator using SCR and TRIAC

4 **4 Hours**

EXPERIMENT 4

Design and Simulation of Dc Jones chopper for Dc Drive Speed control applications.

5 **6 Hours**

EXPERIMENT 5

Simulation and Experimental verification of Resonant Buck/Boost Converter for industrial applications.

6 **4 Hours**

EXPERIMENT 6

Design and Simulation of Zeta converter for Electric Vehicle applications.

7 **4 Hours**

EXPERIMENT 7

Simulation and Experimental verification of Three phase voltage source Inverter for variable frequency drive applications.

8 **6 Hours**

EXPERIMENT 8

Design and Simulation of Single-phase Parallel Inverter with R and RL Loads.

9 **6 Hours**

EXPERIMENT 9

Conduct a FFT analysis for input and output parameter of voltage source inverter with and without filter.

10 **6 Hours**

EXPERIMENT 10

Design and Simulation of 9 level multilevel inverter topology for Power quality improvement.

11 **6 Hours**

EXPERIMENT 11

Simulation of a Multicarrier PWM Technique based Multilevel Inverter for adjustable speed drives.

12 **6 Hours**

EXPERIMENT 12

Design and Simulation of Single-phase Matrix converter for variable frequency applications.

Total: 60 Hours

21PE17 MODELING OF ELECTRICAL MACHINES LABORATORY

0 0 4 2

Course Objectives

- Design of various electrical machines using Ansys Maxwell.
- Develop the mathematical models for electrical machines and simulate it using MATLAB/SIMULINK.
- Analyse the performance of various electrical machines using MATLAB/SIMULINK.

Programme Outcomes (POs)

a. Apply the core knowledge to identify, formulate, and solve problems in Power Electronics and Drives systems.
b. Apply knowledge in mathematics, science, electric and electronic circuits to develop and analyze mathematical models for power electronic converters and controllers.
c. Design power electronic circuits for industrial and commercial applications with due consideration on public health, safety and environmental constraints with sustainability and ethical responsibility.
d. Select and apply appropriate tools for modeling, simulation and analysis of power electronics circuits for renewable energy applications.
e. Attain proficiency in Communication and to work in multidisciplinary team as an individual or leader in Power Electronics and Drives industries.
f. Engage in lifelong learning, plan and conduct a systematic study on significant research with effective utilization of resources.

Course Outcomes (COs)

1. Analyse the performance of Permanent Magnet Synchronous Machine in motoring and generating mode.
2. Analyse the characteristics of Switched Reluctance Motor used in electric vehicles.
3. Analyse the performance of Brushless Direct Current Machine in motoring and generating mode.
4. Apply the stationary reference frame method for modelling of single phase and three phase Induction Machine
5. Apply the rotor reference frame method for modelling of three phase synchronous Machine.

1 **6 Hours**

EXPERIMENT 1
Design and analyze the performance of PMSM using Ansys Maxwell.

2 **6 Hours**

EXPERIMENT 2
Design and analyze the performance of SRM using Ansys Maxwell.

3 **6 Hours**

EXPERIMENT 3
Design and analyze the performance of BLDC motor using Ansys Maxwell.

4 **6 Hours**

EXPERIMENT 4
Design and analyze the performance of DC motor using Ansys Maxwell.

5 **6 Hours**

EXPERIMENT 5

Design and analyze the performance of three phase squirrel cage induction motor using Ansys Maxwell.

6 **6 Hours**

EXPERIMENT 6

Modeling and Simulation of Single phase Induction in the stationary reference frame using MATLAB/SIMULINK.

7 **6 Hours**

EXPERIMENT 7

Modeling and Simulation of three phase induction machine in the stationary reference frame using MATLAB/SIMULINK.

8 **6 Hours**

EXPERIMENT 8

Modeling and Simulation of three phase synchronous machine in the rotor reference frame using MATLAB/SIMULINK.

9 **6 Hours**

EXPERIMENT 9

Current Regulated PWM inverter fed induction motor drive with indirect field oriented control using MATLAB/SIMULINK.

10 **6 Hours**

EXPERIMENT 10

Modeling and Simulation of permanent magnet synchronous Generator using MATLAB/SIMULINK.

Total: 60 Hours

21PE21 SOLID STATE DRIVES AND CONTROL **3 0 0 3**

Course Objectives

- Interpret the converter and chopper control of DC drives
- Illustrate the concept of closed loop control of AC drives
- Application of industrial drives selection

Programme Outcomes (POs)

a. Apply the core knowledge to identify, formulate, and solve problems in Power Electronics and Drives systems.
b. Apply knowledge in mathematics, science, electric and electronic circuits to develop and analyze mathematical models for power electronic converters and controllers.
c. Design power electronic circuits for industrial and commercial applications with due consideration on public health, safety and environmental constraints with sustainability and ethical responsibility.
e. Attain proficiency in Communication and to work in multidisciplinary team as an individual or leader in Power Electronics and Drives industries.
f. Engage in lifelong learning, plan and conduct a systematic study on significant research with effective utilization of resources.

Course Outcomes (COs)

1. Analyze the performance of rectifier and chopper fed dc motor drives considering input and output dynamics.
2. Analyze the different methods of solid state speed control of induction motor drives and compute its control parameters.
3. Apply the open loop and close loop control for synchronous motor fed drives under steady state and dynamic conditions.
4. Analyze the performance of special motor drives with inner current and outer speed control.
5. Analyze the performance of Electrical drives using PID controller.

UNIT I **9 Hours**

SOLID STATE CONTROL OF DC DRIVES

Separately excited dc motor drive: Operation and performance characteristics- single - phase and three phase fully controlled converter - Operation on dual converter. Chopper drive: operation and performance calculation on Class A, class B, Class C, Class D and class E choppers. Types of braking, Closed-loop Operation of DC Drives.

UNIT II **9 Hours**

SOLID STATE CONTROL OF INDUCTION MOTOR DRIVES

Induction motor drive: VSI fed induction motor - Closed-loop Volt/Hz control of induction motor with slip speed regulation, CSI fed induction motor - Closed-loop operation of current source inverter (CSI) fed induction motor drive, Direct Torque control strategy of induction machines - Torque estimation with stator and rotor flux components.

UNIT III **9 Hours**

SYNCHRONOUS MOTOR DRIVE

VSI Fed Synchronous motor drive - Self-control mode - torque angle and marginal angle control. Power factor control - closed loop control of load commutated inverter synchronous motor drive.

UNIT IV **9 Hours**

SPECIAL MOTOR DRIVES

Speed and current control of trapezoidal BLDC motor drive - DSP control of switched reluctance motor drive- Voltage and current control of stepper motor- closed loop control for Stepper motor.

UNIT V **9 Hours**

INDUSTRIAL CONTROL OF ELECTRICAL DRIVES

Phase Lock Loop control of electrical drives, Ac motor drives in transportation system and traction - Implementing PID algorithm using Industrial Controllers Control of DC motor drives, Induction motor drives and stepper motor drives.

FOR FURTHER READING

Transfer function of dc motor - closed loop control of induction motor drives steady state and torque expression of synchronous Motor Current and speed loops - application areas and functions of microprocessors in drive technology .

Total: 45 Hours

Reference(s)

1. Bimal K. Bose, Power Electronics and Motor Drives: Advances and Trends, Academic Press, 2017.
2. Vedam Subramanyam, Electric Drives: Concepts & Applications, Tata McGraw- Hill Education, 2017.
3. Ion Boldea, Syed A. Nasar. Electric Drives, CRC Press, July 2016.
4. S.K.Pillai, A First course on Electrical Drives, Fourth Edition, New Age International Publisher, 2018.
5. R.Krishnan, Electrical Drives, Pearson India, January 2015.

21PE22 DESIGN AND ANALYSIS OF ADVANCED POWER CONVERTERS

3 0 0 3

Course Objectives

- Summarize the fundamental principles of multi-pulse and multi-level converters for power electronics applications.
- Study of pulse generation for converters using different methods of Pulse Width Modulation techniques.
- Identify the principles of Matrix-Frequency converters and applications of advanced power converters in different fields.

Programme Outcomes (POs)

a. Apply the core knowledge to identify, formulate, and solve problems in Power Electronics and Drives systems.
b. Apply knowledge in mathematics, science, electric and electronic circuits to develop and analyze mathematical models for power electronic converters and controllers.
c. Design power electronic circuits for industrial and commercial applications with due consideration on public health, safety and environmental constraints with sustainability and ethical responsibility.

Course Outcomes (COs)

1. Design of diode and SCR based multi pulse converters for reduction of Total Harmonic Distortion.
2. Design of different topologies of multilevel inverters and comparative study of multilevel inverters in suitable applications.
3. Apply the different PWM techniques in various configurations of multilevel inverter for harmonic free operation.
4. Design and analyse the different topologies of Matrix-Reactance frequency converter for different control strategies.
5. Analyse the performance of different advanced power converters in various real time applications.

UNIT I **9 Hours**

MULTIPULSE CONVERTERS

Concept of multi-pulse, Configurations for m-pulse converters, (m=12, 18, 24 ....) series-type and separate-type diode rectifiers, Six-pulse and 12-pulse diode and SCR rectifier, Different phase shifting transformer configurations for multi-pulse converters, Applications.

UNIT II **9 Hours**

MULTI-LEVEL CONVERTERS

Need for multi-level inverters, Concept of multi-level, Topologies for multi-level: Neutral point Clamped, Flying capacitor and Cascaded H-bridge multilevel Converters configurations; Features and relative comparison of these configurations, applications.

UNIT III **9 Hours**

PULSE WIDTH MODULATION SCHEMES FOR MULTI-LEVEL CONVERTERS

Sinusoidal PWM, Hysteresis PWM, Space Vector Modulation PWM, Carrier based PWM schemes for multi-level converters: Phase shifted multi-carrier modulation, Level shifted multi-carrier modulation, Harmonic Reduction Techniques

UNIT IV **9 Hours**

MATRIX CONVERTERS

Review of AC-AC Frequency Converters: Matrix Converter, Indirect AC-AC Frequency Converters without DC Storage Elements, AC-AC Frequency Converters based on Matrix Reactance Chopper Topologies, Hybrid AC-AC Frequency Converters- Control Strategies-Modeling of Matrix Converters- Steady state Analysis-Transient Analysis.

UNIT V **9 Hours**

APPLICATIONS OF ADVANCED POWER CONVERTERS

Converters for HVDC and FACTS devices, Standalone solar inverter, Inverter for wind applications, Converters for Electric Vehicle and Hybrid Vehicle applications, Inverter for induction heating, Converters for Aircraft, Converters for Industrial Drives.

FOR FURTHER READING

Practical issues in power electronic converters: Selection criteria for diodes, MOSFETs and IGBTs; gate drive circuits, Thermal management, EMI Issues, Power Factor Improvement techniques.

Total: 45 Hours

Reference(s)

1. Euzeli cipriano, Edison roberto cabral da silva, Advanced Power Electronic Converters,IEEE Press Wiley, 2015.
2. Muhammad H. Rashid, Power Electronics - Circuits, Devices and Applications, Prentice Hall of India, 3rd ed.,2017.
3. Bin Wu, Mehdi Narimani, High Power Converters and AC Drives, Wiley Inc., 2017.
4. Powel Szczesniak, Three-phase AC-AC Power Converters based on Matrix Converter Topology, Springer Verlog , London,2013.
5. Krishna Kumar Gupta, Pallavee Bhatnagar,Multilevel Inverters: Conventional and Emerging Topologies and Their Control, Elsevier Science, 2017.

21PE23 SWITCHED MODE AND RESONANT CONVERTERS

3 0 0 3

Course Objectives

- Design of Switched-Mode Converters based on steady-state dc and ac ripple specifications.
- Analysis of switched-mode dc-dc converters using transfer function and averaging techniques.
- Design and Analysis of PWM rectifiers and resonant converters.

Programme Outcomes (POs)

a. Apply the core knowledge to identify, formulate, and solve problems in Power Electronics and Drives systems.
b. Apply knowledge in mathematics, science, electric and electronic circuits to develop and analyze mathematical models for power electronic converters and controllers.
c. Design power electronic circuits for industrial and commercial applications with due consideration on public health, safety and environmental constraints with sustainability and ethical responsibility.
d. Select and apply appropriate tools for modeling, simulation and analysis of power electronics circuits for renewable energy applications.

Course Outcomes (COs)

1. Analyse the various regulator topologies for Switched mode power supply.
2. Analyse the characteristics of switched-mode dc-dc power converters under steady-state condition.
3. Analyse the performance of zero voltage and zero current switching resonant converters.
4. Analyse the transfer function of resonant converter under various control schemes.
5. Apply switching power supply techniques in Electronic ballast and computers.

UNIT I **9 Hours**

CONVERTER TOPOLOGIES FOR SMPS

Introduction to Linear Regulators and its Switching- Linear Regulator as Dissipative Regulator-Switching Regulator Topologies- The Boost Switching Regulator Topology- The Polarity Inverting Boost Regulator- Push Pull, Flyback converter and Forward converter.

UNIT II **9 Hours**

INVERTERS MODULATION TECHNIQUES

Switch mode Inverters - Single Phase Inverters - PWM Principles - Bipolar and Unipolar Switching in SPWM, Space vector pulse width modulation- Design of inductor, Isolation transformer and capacitors for power electronic applications, Input filter design.

UNIT III **10 Hours**

SOFT-SWITCHING RESONANT CONVERTERS

Introduction - Basic resonant circuit concepts - Classification - Zero voltage switching buck and boost converters- zero current switching buck and boost converters- Multi resonant converters - Zero voltage switching clamped voltage converters - High frequency link integral half cycle converters - Phase modulated resonant converters.

UNIT IV **8 Hours**

RESONANT CONVERTERS DYNAMIC ANALYSIS

Analysis of converter transfer functions -Design of feedback compensators-current control, frequency control and critical conduction mode control.

UNIT V **9 Hours**

APPLIACTIONS FOR SWITCHING POWER SUPPLY TECHNIQUES

Power Factor and Power Factor Correction: Basic Circuit Details-Integrated Circuit Chips- Electronic Ballasts: High-Frequency Power Regulators for Fluorescent Lamps-Low Input Voltage Regulators for Computers and Portable Electronic: Linear Technology Corporation Boost and Buck Regulators.

FOR FURTHER READING
Review of switching regulators and switch mode power supplies, Uninterrupted power supplies-offline and on-line topologies -Analysis of UPS topologies, solid state circuit breakers, solid-state tap changing of transformer.

Total: 45 Hours

Reference(s)

1. Robert W. Erickson and Dragan Maksimovic, Fundamentals of Power Electronics, Springer, 2nd Edition, 2017.
2. Marian K. Kazimierczuk, Pulse-width Modulated DC-DC Power Converters, John Wiley & Sons Ltd., 3rd Edition, 2018.
3. Philip T Krein, Elements of Power Electronics, Oxford University Press, 4th Edition, 2019.
4. Batarseh, Power Electronic Circuits, John Wiley, 6nd Edition, 2017.
5. Apraham I Pressman, Switching Power Supply Design, McGraw Hill Publishing Company, 2019.

21PE26 ELECTRICAL DRIVES LABORATORY 0 0 4 2

Course Objectives

- Illustrate the working of AC and DC drive with various converter and inverter topologies.
- Analyse the operating performance of special electrical Drives.
- Analyse the performance of advanced DC and AC drives using Siemens Drives.

Programme Outcomes (POs)

b. Apply knowledge in mathematics, science, electric and electronic circuits to develop and analyze mathematical models for power electronic converters and controllers.
c. Design power electronic circuits for industrial and commercial applications with due consideration on public health, safety and environmental constraints with sustainability and ethical responsibility.
d. Select and apply appropriate tools for modeling, simulation and analysis of power electronics circuits for renewable energy applications.
e. Attain proficiency in Communication and to work in multidisciplinary team as an individual or leader in Power Electronics and Drives industries.
f. Engage in lifelong learning, plan and conduct a systematic study on significant research with effective utilization of resources.

Course Outcomes (COs)

1. Analyse the performance of four quadrant operations in converter fed DC motor and working of braking methods.
2. Analyse the operating characteristics of Permanent Magnet Synchronous Motor and Switched Reluctance Motor drives.
3. Analyse the performance characteristics of variable frequency drive and multi-level inverter based induction motor drive.
4. Analyse the closed loop operation and power quality of AC Drive using Siemens S71200 PLC Module and monitoring using HMI.
5. Analyse the position and angular displacement of servo drive using Siemens Sinamics G120 Drive with real time monitoring with HMI and S71200 Siemens PLC.

1 **4 Hours**

EXPERIMENT 1

Experimental Verification of DC-DC converter fed Siemens 6RA80 DC motor drive.

2 **4 Hours**

EXPERIMENT 2

Design and Verification of Closed Loop Sensor less control for BLDC motor with Siemens S71200 PLC and HMI.

3 **6 Hours**

EXPERIMENT 3

Design and Verification of Speed Control of SRM motor drive with Siemens S71200 PLC and HMI.

4 **6 Hours**

EXPERIMENT 4

Experimental Verification of Power Quality Analysis of Variable frequency AC drive using Siemens Sinamics G120 Drive.

5 **4 Hours**

EXPERIMENT 5

Design and Verification of Multi-Level Inverter based Siemens G120 Induction Motor Drive.

6 **4 Hours**

EXPERIMENT 6

Experimental Verification of Closed loop V/F control and direction control of induction motor by S71200 Siemens PLC with HMI system.

7 **6 Hours**

EXPERIMENT 7

Experimental Verification of Closed loop Speed control of DC separately Excited motor using 6RA80 Siemens DC Drive.

8 **6 Hours**

EXPERIMENT 8

Experimental Verification of Angular and position control of Servo motor using Sinamics S120 Drive.

9 **4 Hours**

EXPERIMENT 9

Design and Verification of Soft Switching of Induction motor drive using Siemens S7 1200 PLC.

10 **4 Hours**

EXPERIMENT 10

Design and Verification of Speed Controller for stepper motor using Siemens S7 1200 PLC with HMI.

11 **6 Hours**

EXPERIMENT 11

Experimental Verification of Buck / Boost converter based Siemens 6RA80 DC Drive.

12 **6 Hours**

EXPERIMENT 12

Design and Verification of Real time monitoring of conveyer belt drive application using S71200 Siemens PLC with HMI.

Total: 60 Hours

21PE27 MINI PROJECT 0 0 4 2

Course Objectives

- Understand real world problem, identify the requirement and develop the design solutions.
- Use the new tools, algorithms, techniques that contribute to obtain the solution of the project.
- Validate through conformance of the developed prototype and analysis the cost effectiveness.

Programme Outcomes (POs)

a. Apply the core knowledge to identify, formulate, and solve problems in Power Electronics and Drives systems.
b. Apply knowledge in mathematics, science, electric and electronic circuits to develop and analyze mathematical models for power electronic converters and controllers.
c. Design power electronic circuits for industrial and commercial applications with due consideration on public health, safety and environmental constraints with sustainability and ethical responsibility.
d. Select and apply appropriate tools for modeling, simulation and analysis of power electronics circuits for renewable energy applications.
e. Attain proficiency in Communication and to work in multidisciplinary team as an individual or leader in Power Electronics and Drives industries.
f. Engage in lifelong learning, plan and conduct a systematic study on significant research with effective utilization of resources.

Course Outcomes (COs)

1. Formulate a real world problem, identify the requirement and develop the design solutions.
2. Identify technical ideas, strategies and methodologies.
3. Utilize the new tools, algorithms, techniques that contribute to obtain the solution of the project.
4. Test and validate through conformance of the developed prototype and analysis the cost effectiveness.
5. Prepare report and present oral demonstrations.

Total: 60 Hours

21PE33 DISSERTATION PHASE I **0 0 20 10**

Course Objectives

- Identify a real world problem converted to a technical problem and acquire knowledge on methodology to solve the problem.
- Apply new tools and techniques required for solving identified problem.
- Analysis of the results obtained and Effectively communicate information relating to all aspects of the design process in written, oral, and graphical form.

Programme Outcomes (POs)

a. Apply the core knowledge to identify, formulate, and solve problems in Power Electronics and Drives systems.
b. Apply knowledge in mathematics, science, electric and electronic circuits to develop and analyze mathematical models for power electronic converters and controllers.
c. Design power electronic circuits for industrial and commercial applications with due consideration on public health, safety and environmental constraints with sustainability and ethical responsibility.
d. Select and apply appropriate tools for modeling, simulation and analysis of power electronics circuits for renewable energy applications.
e. Attain proficiency in Communication and to work in multidisciplinary team as an individual or leader in Power Electronics and Drives industries.
f. Engage in lifelong learning, plan and conduct a systematic study on significant research with effective utilization of resources.

Course Outcomes (COs)

1. Apply the in-depth knowledge and skills gained to identify the technical enhancement for addressing of real world problem.
2. Select suitable methodologies to produce a defined research design and its justification to carry out the proposed problem.
3. Analyse and validate the technical findings of the proposed solution.
4. Presenting the work in International/ National conference or reputed journals
5. Effectively preparing Dissertation report in required standards.

Total: 300 Hours

21PE41 DISSERTATION PHASE II 0 0 28 14

Course Objectives

- Identify a real world problem converted to a technical problem and acquire knowledge on methodology to solve the problem.
- Apply new tools and techniques required for solving identified problem.
- Analysis of the results obtained and Effectively communicate information relating to all aspects of the design process in written, oral, and graphical form.

Programme Outcomes (POs)

a. Apply the core knowledge to identify, formulate, and solve problems in Power Electronics and Drives systems.
b. Apply knowledge in mathematics, science, electric and electronic circuits to develop and analyze mathematical models for power electronic converters and controllers.
c. Design power electronic circuits for industrial and commercial applications with due consideration on public health, safety and environmental constraints with sustainability and ethical responsibility.
d. Select and apply appropriate tools for modeling, simulation and analysis of power electronics circuits for renewable energy applications.
e. Attain proficiency in Communication and to work in multidisciplinary team as an individual or leader in Power Electronics and Drives industries.
f. Engage in lifelong learning, plan and conduct a systematic study on significant research with effective utilization of resources.

Course Outcomes (COs)

1. Apply the in-depth knowledge and skills gained to identify the technical enhancement for addressing of real world problem.
2. Select suitable methodologies to produce a defined research design and its justification to carry out the proposed problem.
3. Analyse and validate the technical findings of the proposed solution.
4. Presenting the work in International/ National conference or reputed journals
5. Effectively preparing Dissertation report in required standards.

Total: 420 Hours

21PE51 POWER QUALITY MONITORING AND MITIGATION TECHNIQUES 3 0 0 3

Course Objectives

- Illustrate the various power quality phenomenon, their origin and effects.
- Interpret the various power quality monitoring systems and standards.
- Analyse different methodologies for detection and mitigation of power quality problems using FACTS devices.

Programme Outcomes (POs)

a. Apply the core knowledge to identify, formulate, and solve problems in Power Electronics and Drives systems.
b. Apply knowledge in mathematics, science, electric and electronic circuits to develop and analyze mathematical models for power electronic converters and controllers.
c. Design power electronic circuits for industrial and commercial applications with due consideration on public health, safety and environmental constraints with sustainability and ethical responsibility.

Course Outcomes (COs)

1. Analyses the characteristics of various power quality problems in domestic and industrial applications with source of generation.
2. Analyses the impacts of power quality issues in balanced, unbalanced, linear and nonlinear loads.
3. Apply the different methodologies for monitoring and control of power quality problems in transmission and distribution systems.
4. Analyses the performance of passive shunt and series filters for mitigating the power quality issues generated in power systems.
5. Analyses the performance of various FACTS devices to eliminate voltage and current quality issues in distribution system.

UNIT I **9 Hours**

INTRODUCTION TO POWER QUALITY

Electric power quality phenomena. Classifications, characteristics and causes of short duration variation like sag, swell and interruption - Long duration variation like under voltage, over voltage and sustained interruption - Transients, voltage imbalance, power frequency variations and waveform distortion like harmonics and DC offset.

UNIT II **9 Hours**

CAUSES AND IMPACTS OF POWER QUALITY ISSUES

Voltage sag due to faults, induction motor starting and transformer energizing. Over voltages due to capacitor switching, lightning and ferro resonance. Harmonic sources from commercial and industrial loads. Classification and analysis of nonlinear loads. Effects of various power quality issues.

UNIT III **9 Hours**

POWER QUALITY MONITORING AND STANDARDS

Monitoring considerations. Power Quality Measurement - wiring and grounding test devices, disturbance analyzers, Harmonic / spectrum analyzers and flicker meters. Smart power quality monitors, Expert system for power quality monitoring - IEEE and IEC standards.

UNIT IV **9 Hours**

PASSIVE COMPENSATION

Passive power filters - classifications, operations, design, modeling and performance analysis of passive shunt and series filters.

UNIT V **9 Hours**

ACTIVE COMPENSATION

FACTS devices: Classifications, operation, control methods, design and performance analysis of DSTATCOMs, DVRs and UPQCs.

FOR FURTHER READING

Estimation of voltage sag performance - Protection of overhead line, underground cables and transformers - Sag and harmonic indices - Harmonic distortion evaluation - Loads that causes the power quality problems.

Total: 45 Hours

Reference(s)

1. Roger. C. Dugan, Mark. F. McGranagham, Surya Santoso, H.Wayne Beaty, Electrical Power Systems Quality, McGraw Hill, 2017.
2. Bhim Singh, Ambrish Chandra, Kamal Al-Haddad, Power Quality: Problems and Mitigation Techniques, John Wiley & Sons, 2015.
3. Arrillaga, J, Watson, N.R., Chen, S., Power System Quality Assessment, Wiley, New York, 2011.
4. M.H.J Bollen, Understanding Power Quality Problems: Voltage Sags and Interruptions, New York: IEEE Press, 2011.
5. C.Sankaran, CRC Press, Power Quality, New York, 2002.

21PE52 SPECIAL ELECTRICAL MACHINES 3 0 0 3

Course Objectives

- Outline the construction and operational characteristics of special electrical machines.
- Select the suitable controller for the closed loop control of special machines.
- Interpret the static and dynamic characteristics of special machines for industrial applications.

Programme Outcomes (POs)

a. Apply the core knowledge to identify, formulate, and solve problems in Power Electronics and Drives systems.
b. Apply knowledge in mathematics, science, electric and electronic circuits to develop and analyze mathematical models for power electronic converters and controllers.
c. Design power electronic circuits for industrial and commercial applications with due consideration on public health, safety and environmental constraints with sustainability and ethical responsibility.

Course Outcomes (COs)

1. Analyze the characteristics of a synchronous reluctance and universal motors.
2. Analyze the control technique and operating characteristics of switched reluctance motor.
3. Analyze the characteristics of permanent magnet synchronous motors.
4. Evaluate the performance parameters of permanent magnet brushless dc motors.
5. Analyze the performance characteristics of special machines and select a suitable machine for Electric Traction and Electric Vehicle Applications.

UNIT I **9 Hours**

SYNCHRONOUS RELUCTANCE AND UNIVERSAL MOTORS

Constructional features: axial and radial air gap Motors - Operating principle - Reluctance Torque-Phasor diagram - Motor characteristics. Universal motors - Operating principle - Applications -torque speed characteristics - Essential parts of universal motors.

UNIT II **9 Hours**

SWITCHED RELUCTANCE MOTORS

Constructional features, Principle of operation, Torque equation, Power controllers, Characteristics and control, Microprocessor based controller.

UNIT III **9 Hours**

PERMANENT MAGNET SYNCHRONOUS MOTORS

Construction, Principle of operation - Surface permanent magnet (square and sinusoidal back emf type) and interior permanent magnet machines. EMF, Power input and Torque expressions-phasor diagram - Power Controllers, Torque Speed characteristics, Self-control, Vector Control, Current Control Schemes.

UNIT IV **9 Hours**

PERMANENT MAGNET BRUSHLESS DC MOTORS

Permanent magnet materials, Magnetic characteristics, Commutation in DC motors, Difference between mechanical and electronic commutators, Hall sensors, Optical sensors, Multiphase brushless motors, Square wave permanent magnet brushless motor drives, Torque and EMF equation, Torque - speed characteristics, Controllers - Microprocessor based Controller.

UNIT V **9 Hours**

APPLICATIONS OF SPECIAL MACHINES

PMSM - Electric Traction Applications, PMBLDC motor - Electric vehicle, Space craft applications, Switched Reluctance Motor - Automotive, Domestic, Aerospace, Servo Applications, Synchronous Reluctance Motor - Pumps, Synchronized Conveyers.

FOR FURTHER READING

Comparative study of interior permanent magnet, Induction and Switched Reluctance Motor Drives for Electric Vehicle and Hybrid Electric Vehicle Applications, Hybrid Photovoltaic Thermoelectric Generator powered Synchronous Reluctance Motor for Pumping Applications.

Total: 45 Hours

Reference(s)

1. 1Berker Bilgin, James Weisheng Jiang, Ali Emadi, Switched Reluctance Motor Drives Fundamentals to Applications, CRC Press, November 2018.
2. R. Krishnan, Permanent Magnet Synchronous and Brushless DC Motor Drives, CRC Press,2009.
3. Jacek Gieras, Permanent Magnet Motor Technology Design and Applications, CRC Press,2010.
4. J.R. Hendershot, T.J.E. Miller, Design of Brushless Permanent Magnet Machines, Prentice Hall of India, March 2010.
5. E.G. Janardanan, Special Electrical Machines, PHI learning Private Limited, New Delhi 2014.

21PE53 POWER CONVERTERS FOR RENEWABLE ENERGY SYSTEMS **3 0 0 3**

Course Objectives

- Summarize the necessity of renewable energy resources and government policies.
- Explain the principle, types and configurations of solar PV and wind energy conversion system.
- Design a micro grid using hybrid renewable power generators.

Programme Outcomes (POs)

a. Apply the core knowledge to identify, formulate, and solve problems in Power Electronics and Drives systems.
b. Apply knowledge in mathematics, science, electric and electronic circuits to develop and analyze mathematical models for power electronic converters and controllers.
c. Design power electronic circuits for industrial and commercial applications with due consideration on public health, safety and environmental constraints with sustainability and ethical responsibility.

Course Outcomes (COs)

1. Analyze the availability of renewable energy resources and its related schemes.
2. Analyze the performance of power converters in solar PV conversion system
3. Analyze the different power conditioning schemes of wind energy conversion system.
4. Analyze the synchronization methods for grid connected solar PV and wind energy conversion system.
5. Analyze the control and protection techniques used in microgrid.

UNIT I **8 Hours**

INTRODUCTION

World energy scenario- Conventional and renewable sources- Wind, solar, hydro, geothermal availability and power extraction. Qualitative study of different renewable energy resources- Need to develop new energy technologies- MNRE Rules and Regulations.

UNIT II **9 Hours**

SOLAR PHOTOVOLTAIC ENERGY CONVERSION SYSTEM

Solar PV Panels and its classifications - characteristics- Influence of insolation, temperature- Importance of bypass and blocking diodes- Parasitic capacitance and shadowing effect-Maximum power point tracking Algorithms - Power conditioning schemes -DC-DC converters-bidirectional converters, Interleaved and multi-input converters- Inverters - Design of Solar PV systems- Low voltage Ride Through (LVRT)- Introduction to grid tied and standalone solar PV system.

UNIT III **9 Hours**

WIND ENERGY CONVERSION SYSTEMS

Basic principle of Wind Energy Conversion System- Components of Wind Energy Conversion System-Generators for WECS-Classification of WECS-Self excited induction generator - synchronous generator - Modern wind generators-Power conditioning schemes-Power extraction and MPPT schemes-Wheeling and Banking strategies- Standalone Systems

UNIT IV **10 Hours**

GRID CONNECTED WECS AND SPVECS

Grid connected systems-Grid related problems - Grid Codes - Optimal PV & Wind Sizing-Grid integrated WECS & SPVECS -Power converters for Grid connected WECS and SPVECS-Matrix converters -Single and three phase inverters with and without transformer, Heric, H6, Multilevel Neutral point clamp-Modular multilevel- Parallel power processing- PLL and synchronization.

UNIT V **9 Hours**

DISTRIBUTED POWER SYSTEMS

Introduction to Microgrids-Microgrid layouts- DC Electronic Transformer- Intelligent Local Controllers- Traditional Frequency Control & Local Control- Protection Devices, Criteria, Methods and Grounding-Faults in Microgrids.

FOR FURTHER READING

Intelligent controllers for distributed systems, Harmonic mitigation techniques, electric vehicles, Design of active and passive filters.

Total: 45 Hours

Reference(s)

1. Mukund R Patel, Wind and Solar Power Systems, CRC Press 2, Revised 2010.
2. Ahmed F. Zobaa, Ramesh C. Bansal, Handbook of Renewable Energy Technology, World Scientific,2011.
3. Rakosh Das Begamudre, Energy Conversion Systems, New Age International, 2007.
4. Chetan Singh Solanki, Solar Photovoltaic Technology and Systems, PHI Learning Private Ltd, 2015.
5. Toshihisa Funabashi, Integration of Distributed Energy Resources in Power Systems: Implementation, Operation and Control, Academic Press, 2016.

21PE54 ELECTRIC VEHICLES AND ENERGY STORAGE SYSTEMS **3 0 0 3**

Course Objectives

- Acquire knowledge of Electric vehicle and its drive train system along with its history and the policies.
- Recognize the various control strategies and the converters used for propulsion and the sizing of the drive system.
- Understand the principle and operation of Lithium ion battery used for energy storage in electric vehicles and its management strategies.

Programme Outcomes (POs)

a. Apply the core knowledge to identify, formulate, and solve problems in Power Electronics and Drives systems.
b. Apply knowledge in mathematics, science, electric and electronic circuits to develop and analyze mathematical models for power electronic converters and controllers.
c. Design power electronic circuits for industrial and commercial applications with due consideration on public health, safety and environmental constraints with sustainability and ethical responsibility.

Course Outcomes (COs)

1. Analyze the characteristics of power train component and compute the mathematical model to describe vehicle performance.
2. Apply the concept of drive and propulsion used in electric vehicles and select a suitable motor for the drive train.
3. Analyze the sizing of drive system and the associated power converters used in the electric vehicles.
4. Analyze the characteristics of Lithium ion battery and evaluate the energy storage requirements in electric vehicles.
5. Analyze the performance of various charging techniques used in V2X with networking and mobility.

UNIT I **9 Hours**

INTRODUCTION

History of electric vehicles - EV Policies in India - Basics of Conventional vehicle propulsion - mechanics and traction - Vehicle power source - characterization and transmission characteristics - Power train components - Mathematical models to describe vehicle performance.

UNIT II **9 Hours**

DRIVE TRAIN

Basic concept of electric traction - Electric drive-train topologies - Power flow control - Overall Efficiency analysis - Electric components in EV - Configuration and control of DC Motor, Induction Motor, Permanent Magnet Motor and Switched Reluctance Motor drives - Drive system efficiency.

UNIT III **9 Hours**

DRIVE SYSTEM SIZING AND POWER CONVERTERS

Matching the electric machine and the internal combustion engine- Sizing the propulsion motor and power electronics- Selecting the energy storage technology - Communications and supporting subsystems - DC/DC Converters - Fourth Order DC/DC Converters - Power train boost and Cell Balancing - Traction inverter for electric vehicle.

UNIT IV **9 Hours**

LITHIUM BATTERY

Introduction to Energy Storage Requirements - Battery Fundamentals - Parameters and Modeling - Li-ion batteries - Principle of operation - Battery components and design - Battery fabrications - Hydrogen Fuel Cells for EV - Regulations and Safety Aspects of High Voltage Batteries.

UNIT V **9 Hours**

BATTERY CHARGING

Battery Charging techniques - Modes - EV charging standards - V2G, G2V, V2B, V2H - Power Control Strategies - Charging Infrastructure - Battery Chargers and Battery Testing Procedures - Automotive networking and communication - E mobility business - electrification challenges - Connected Mobility and Autonomous Mobility.

FOR FURTHER READING

Technology and economic aspects of battery recycling - E-mobility Indian Roadmap Perspective - EVs in infrastructure system - Integration of EVs in smart grid - Social dimensions of EVs.

Total: 45 Hours

Reference(s)

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 3rd Edition, 2021.
2. Mehrdad Ehsani, Yimi Gao,SebastianE.Gay, Ali Emadi, Modern Electric and Fuel Cell Vehicles, Theory and Design, CRC Press, 3rd Edition, 2018.
3. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2012.
4. Ali Emadi, Advanced Electric Drive Vehicles, CRC Press, 1st Edition, 2017.
5. Sheldon S. Williamson, Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles, Springer, 2013.

21PE55 CONTROL AND INTEGRATION OF RENEWABLE ENERGY SOURCES

3 0 0 3

Course Objectives

- Interpret the performance of electric grid during integration of different renewable energy sources with its storage technologies
- Model and analyze the renewable energy based system for electrical grid with real and reactive power control
- Develop an optimized hybrid integrated system for electrical grid and analyze the performance of power electronic converters.

Programme Outcomes (POs)

a. Apply the core knowledge to identify, formulate, and solve problems in Power Electronics and Drives systems.
b. Apply knowledge in mathematics, science, electric and electronic circuits to develop and analyze mathematical models for power electronic converters and controllers.
c. Design power electronic circuits for industrial and commercial applications with due consideration on public health, safety and environmental constraints with sustainability and ethical responsibility.

Course Outcomes (COs)

1. Analyze the effects of different renewable energy sources on grid with environmental factor and its requirements.
2. Analyse the dynamic and static energy conversion devices with different storage technologies.
3. Analyze and model the basic control strategies required for grid connection.
4. Analyze the technological aspects of power converters for standalone/grid connected system.
5. Apply and develop an optimized integrated system with its stability analysis.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6
1	2	1				
2	2	2				
3	1		2			
4		2	3			
5		2	3			

UNIT I **9 Hours**

INTRODUCTION

Electric grid introduction - Supply guarantee and power quality, Stability, Effects of renewable energy penetration into the grid - Boundaries of the actual grid configuration - Renewable energy resource assessment - feasibility analysis - environmental factors and regulatory requirements, interfacing requirements.

UNIT II **9 Hours**

DYNAMIC AND STATIC ENERGY CONVERSION TECHNOLOGIES

Introduction to different energy conversion technologies - gas and micro turbines - hydro and wind based generation technologies - photovoltaic based generators, different storage technologies such as batteries, fly wheels and ultra capacitors - plug-in-hybrid vehicles - control and integrated operation of different dynamic and static energy conversion devices

UNIT III **9 Hours**

REAL AND REACTIVE POWER CONTROL

Control issues and challenges in Disel,PV,Wind and fuel based Generators-PLL-Modulation Techniques-Dimensioning of filters -Liner and Nonlinear controllers, predictive controllers and adaptive controllers-Fault ride through capabilities, Load frequency and Voltage control.

UNIT IV **9 Hours**

INTEGRATED ENERGY SYSTEMS

System Aspects of Integration: voltage effects, thermal effects, fault level. Islanding - Stand Alone Systems, Case studies of standalone system - Hybrid and integrated energy systems - Mathematical Modelling of Integrated Energy Systems - Technological aspects of power electronic systems connection to the grid - Operational issues associated with integrated energy systems; installation and monitoring; performance analysis.

UNIT V **9 Hours**

INTEGRATION OF DIFFERENT ENERGY CONVERSION TECHNOLOGIES

Resources evaluation and needs, Dimensioning integration systems - Optimized integrated systems - Integrated control of different resources - Distributed versus Centralized Control - Synchro Converters - Grid connected and Islanding Operations, stability and protection issues, load sharing, Cases studies.

FOR FURTHER READING

Fuel cells and its types, low, medium and high temperature fuel cells, power generation by fuel cells, applications of fuel cells, future potential of fuel cells.

Total: 45 Hours

Reference(s)

1. Ali Keyhani Mohammad N. Marwali and Min Dai, " Integration of Green and Renewable Energy in Electric Power Systems", John Wiley publishing company, 2009.
2. Gilbert M. Masters, "Renewable and Efficient Electric Power Systems", IEEE-Wiley Publishers, 2013.
3. Quing-Chang Zhong and Tomas Hornik "Control of Power Inverters in Renewable Energy and Smart Grid Integration", Wiley, IEEE Press, 2012.
4. Bin Wu, Yongqiang Lang, Navid Zargari and Samir Kouro "Power Conversion and Control of Wind Energy Systems", Wiley 2011.
5. Math H.J. Bollen and Fainan Hassan,"Integration of Distributed Generation in the Power Systems",Wiley 2011.

21PE56 BATTERY MANAGEMENT SYSTEMS 3 0 0 3

Course Objectives

- Illustrate the architecture of battery management systems and its components.
- Explain the attributes and measuring units in battery management systems.
- Represent the process of BMS design in Electric vehicles.

Programme Outcomes (POs)

a. Apply the core knowledge to identify, formulate, and solve problems in Power Electronics and Drives systems.
b. Apply knowledge in mathematics, science, electric and electronic circuits to develop and analyze mathematical models for power electronic converters and controllers.
c. Design power electronic circuits for industrial and commercial applications with due consideration on public health, safety and environmental constraints with sustainability and ethical responsibility.

Course Outcomes (COs)

1. Analyse the various performance parameters of battery packs and select a suitable protection scheme for battery management system.
2. Apply the standard and optimized procedures to estimate the state of charge for battery pack used in real time applications.
3. Analyse the different cell balancing circuits for equal charge distribution in battery packs.
4. Analyse the methods of communication and thermal management system for BMS.
5. Design the battery management systems for electric vehicles applications.

UNIT I **9 Hours**

BATTERY MANAGEMENT SYSTEM REQUIREMENTS

Introduction to Battery management systems - Battery Pack topology - BMS design requirements - Battery Pack Sensing: Voltage, Current, Temperature - Requirements in Charger control - Protection - Estimation requirements: State of charge (SoC), Power, Energy.

UNIT II **9 Hours**

BATTERY STATE ESTIMATION

Definition of SoC - SoC estimation - Basic approaches to estimate SoC - sequential probabilistic methods - Linear and extended Kalman filter (EKF) - problems associated with EKF - Real world issues pertaining to sensors, initialization.

UNIT III **9 Hours**

CELL BALANCING SYSTEM

Cause for cell unbalance - Cell balancing - active balancing: Charge Shuttle (Flying Capacitor) Charge Distribution, Inductive Shuttle Charge Distribution - passive balancing: circuits for balancing - Self balancing - Lossless balancing.

UNIT IV **9 Hours**

COMMUNICATION AND THERMAL MANAGEMENT SYSTEMS

Components used for communication - Data bus: RS232, EIA485 connection - I2C bus - CAN bus - LIN bus - PLC systems - Flex Ray bus - SM bus - Thermal effects on batteries - Heat sources and sinks - sensors for temperature measurement.

UNIT V **9 Hours**

BMS FOR ELECTRIC VEHCILES

Basic data collection from EV battery pack - charge discharge limits - current settings in BMS - Nominal resistance and calculation - Isolation fault detection - busbar compensation - EV Charging interface with BMS.

FOR FURTHER READING

Wireless BMS,Intelligent BMS,Power electronics based BMS systems, Charger controller in BMS,TI BMS.

Total: 45 Hours

Reference(s)

1. Phillip Weicker, A systems approach to Lithium - ion Battery Management, Artech House Publications, 2014.
2. Gregory L Plett, Battery Management systems - Equivalent circuit methods, Volume 2, Artech House Publications, 2016.
3. Davide Andrea, Battery Management Systems for Large Lithium-ion Battery Packs, Artech House Publications, 2010.
4. Jinchun Jiang, Caiping Zhang, Fundamentals and applications of Lithium Ion batteries in Electric drive vehicles, Willey Publications, 2015.
5. Application Note: Orion BMS 2, EWERT Energy Systems

21PE57 HARMONICS FILTER DESIGN 3 0 0 3

Course Objectives

- Interpret the concept of harmonics to analyse the power quality supplied to electrical equipment.
- Apply the methodologies involved in solving problems related to harmonics.
- Develop harmonic filters to mitigate and control harmonics in the real world and provide appropriate solutions.

Programme Outcomes (POs)

a. Apply the core knowledge to identify, formulate, and solve problems in Power Electronics and Drives systems.
b. Apply knowledge in mathematics, science, electric and electronic circuits to develop and analyze mathematical models for power electronic converters and controllers.

Course Outcomes (COs)

1. Analyse the sources and effects of harmonics for drive applications.
2. Analyse the various methods of harmonics measurements during interaction of AC system and load.
3. Apply the harmonic elimination techniques using multi pulse converters and series rectors in power converter system.
4. Design the active filter with two axis modelling to eliminate harmonics in the power system.
5. Design the passive filter and analyse the harmonic effects in load distributions in industrial and domestic power flow conditions.

UNIT I **9 Hours**

SOURCES AND EFFECTS OF HARMONICS

Introduction to harmonics-linear and non-linear loads-power quality indices: Source of harmonics-harmonics standards. Electromagnetic Interference, Pulsating Torque in AC Drive, Power Quality Indices, Traditional and future sources of harmonics, Standardization of harmonics levels. Effects of Harmonics: Thermal effects on electrical machines – transformer -Rotating machines- Effects on communication system - Harmonic Losses in Equipment-Resistive Elements-K Factor- Transformers-Rotating Machines.

UNIT II **9 Hours**

HARMONICS MEASUREMENT AND ANALYSIS

Methods of harmonics measurement- Harmonic source representation- Harmonic Propagation facts-flux of harmonic currents- Interrelation between AC system and Load - Analysis methods- examples of harmonics analysis.

UNIT III **9 Hours**

HARMONICS MITIGATION AND ELIMINATION TECHNIQUES

Harmonic Cancellation through use of Multi pulse Converters-Series Reactors as Harmonic Attenuator Elements- Phase Balancing. Harmonics Elimination Techniques: Selective harmonic elimination- Modulation based harmonics elimination technique- optimal PWM technique.

UNIT IV **9 Hours**

DESIGN OF ACTIVE FILTERS

Types of active power filter- Suppression of harmonics using active power filters - topologies and their control methods- Single Phase Shunt Current Injection type filter and its control -Three phase three-wire and four-wire shunt active filtering and their control using p-q theory and d-q modelling - Introduction to Hybrid Filter.

UNIT V **9 Hours**

DESIGN OF PASSIVE FILTERS

Types of Passive Filters-Design and Analysis of single tuned and Band Pass Filter- Tuned harmonic filter. Case Studies: Harmonic analysis and filters for residential loads, Industrial loads and commercial loads.

FOR FURTHER READING

Delta-wye and delta-delta connections of transformers, Relation between AC system and load parameters.

Total: 45 Hours

Reference(s)

1. Francisco C. De La Rosa, Harmonics, Power Systems, and Smart Grids, 2nd edition, CRC Press, Taylor& Francis group, January 2017.
2. Jos Arrillaga, Neville. R. Watson, Power System Harmonics, 2nd Edition, John Wiley & Sons, November 2003.
3. Hirofumi Akagi, Edson Hirokazu Watanabe, Mauricio Aredes, Instantaneous Power Theory and Applications to Power Conditioning, 2nd Edition, Wiley-IEEE Press, March 2017.
4. S.A. Pactitis, Active Filters: Theory and Design, 1st Edition, CRC Press , September 5, 2019.
5. Enrique Acha, Manuel Madrigal, Power Systems Harmonics: Computer Modelling and Analysis, John Wiley and Sons Ltd., June 2001.

21PE58 ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY

3 0 0 3

Course Objectives

- Acquire basic knowledge on electromagnetic interference and electromagnetic Compatibility in power converter circuits.
- Analyse the importance of EMI and EMC control techniques.
- Interpret the Noise suppression and EMI filter methods for Power electronic circuits.

Programme Outcomes (POs)

a. Apply the core knowledge to identify, formulate, and solve problems in Power Electronics and Drives systems.
b. Apply knowledge in mathematics, science, electric and electronic circuits to develop and analyze mathematical models for power electronic converters and controllers.
c. Design power electronic circuits for industrial and commercial applications with due consideration on public health, safety and environmental constraints with sustainability and ethical responsibility.

Course Outcomes (COs)

1. Analyze the electromagnetic interference produced through various sources.
2. Apply the electromagnetic interference measurement methods using classical and modern approach with the international standards.
3. Apply various testing methods of electromagnetic interference and analyze the EMI generated from solid state devices and power converter circuits.
4. Analyze the different mitigation techniques to suppress the electromagnetic interference.
5. Design an electromagnetic interference filter to suppress the noises under different conditions.

UNIT I **9 Hours**

INTRODUCTION

Introduction to EMI,EMC and ESD, Intra and inter system EMI, Description of electromagnetic disturbances, Elements of Interference: Disturbances by Frequency Content, Character and Transmission mode.

UNIT II **9 Hours**

MEASURING INSTRUMENTS AND STANDARDS

EMI Measuring Instruments: Measuring the Interference Voltage and Current, Measuring Impulses, Spectrum Analyzers, EMI Measurements for Consumer Appliances, Need for Standards, EMI/EMC Standards-MILSTD461/462, IEEE/ANSI, CISPR/IEC.ISO standards on automotive EMC issues - EMI Standardizing for different application.

UNIT III **9 Hours**

EMI IN POWER ELECTRONIC CIRCUIT AND TESTING METHODS

EMI from Power Semiconductors, and Power Converters, EMI Calculation EMI Testing, EMI Shielding effectiveness tests, Open field test, TEM cell for immunity test, shielded chamber, Shielded anechoic chamber.

UNIT IV **9 Hours**

MITIGATION TECHNIQUES

Influence of Layout and Control of Parasitics, Working principle of Shielding, LF Magnetic shielding, Apertures and shielding effectiveness, Gasketting and sealing, PCB Level shielding, Principle of Grounding. Noise suppression in AC Switching Relays, RC -Snubbers to Power Semiconductors, Shielded Transformers and Capacitor Filters

UNIT V **9 Hours**

EMI FILTER CIRCUIT

Definition of EMI Filter Parameters, EMI Filter Circuit and Design for Insertion Loss, Calculation of Case Insertion Loss, Design Method for Mismatched Impedance Condition, Design Method for EMI Filters with Common- Mode Choke Coils, Damped EMI Filters and Lossy Filter Elements

FOR FURTHER READING

Testing for Susceptibility to Power Line Disturbances, Surge Voltages, Electromagnetic Coupling Reduction Methods, Wiring Layout Methods to Reduce EMI Coupling, PCB Design Considerations. Energy Content of Transient Disturbances, Impulse Characteristics and Noise Filter Design, Surge Protection Devices.

Total: 45 Hours

Reference(s)

1. Francois Costa, Eric Laboure, Bertrand Revol , Electromagnetic Compatibility in Power Electronics, Wiley, 2014.
2. M. H. Rashid, Power electronics Handbook, PHI,2011.
3. Bruce Archambeault, Colin Brench, Omar M. Ramahi, EMI/EMC computational modeling handbook, Kluwer press, second edition, 2001.
4. D. Morgan, A Handbook for EMC Testing and Measurement, IET Electrical Measurement Series, Band 8, 1994.
5. Tim Williams, EMC for product designers, Newnes press, fifth edition, 2016.

21PE59 MODERN CONTROLLERS FOR INDUSTRIAL DRIVES

3 0 0 3

Course Objectives

- Exemplify the importance of PLC and DCS concepts based control of drives.
- Illustrate the working of FPGA based controls.
- Interpret ARM and DSP based control of electrical Machines.

Programme Outcomes (POs)

a. Apply the core knowledge to identify, formulate, and solve problems in Power Electronics and Drives systems.
b. Apply knowledge in mathematics, science, electric and electronic circuits to develop and analyze mathematical models for power electronic converters and controllers.
d. Select and apply appropriate tools for modeling, simulation and analysis of power electronics circuits for renewable energy applications.

Course Outcomes (COs)

1. Apply the concept of Micro controllers and VB.net for interfacing the PLC motor controls.
2. Apply the Computer Numerical System, SCADA and Distributed Control system in industrial drives control.
3. Apply FPGA and VHDL programming for control of DC drives.
4. Apply the control strategies of ARM processor and RTOS for various industrial drives.
5. Analyze the digital control with filters for industrial drives.

UNIT I **9 Hours**

PLC BASED INDUSTRIAL CONTROL

PLC architecture, Ladder logic Programming, Programming based on Timer and Counter, PLC Interface, Introduction to open source LD ladder software- PLC Hardware design using Micro controllers - GUI using VB.net interfacing PLC

UNIT II **9 Hours**

COMPUTER NUMERICAL AND DISTRIBUTED CONTROL SYSTEMS

Basic CNC Principle, servo control for motion axes. Introduction to SCADA. Basics DCS introduction, DCS components/block diagram, DCS specification, latest trend and developments. Automotive DCS.

UNIT III **9 Hours**

FPGA BASED CONTROLS

FPGA-architectures-Types of FPGA , Xilinx XC3000 series ,Configurable logic Blocks (CLB), Input/ Output Block (IOB) , overview of Spartan 3E - Introduction to VHDL programming-simple programs-Closed loop control of DC motor-controller design using FPGA

UNIT IV **9 Hours**

ARM PROCESSOR AND RTOS BASED MACHINE CONTROL

Introduction of ARM Controller LPC2148 - ARM7 Architecture -Instruction Set - Simple Programming-Introduction to RTOS-RTOS based task management Programming-Interfacing of peripherals LCD, Keypad, ADC, DAC and PWM Module.

UNIT V **9 Hours**

DSP PROCESSOR BASED MACHINE CONTROL

Introduction to the DSP core - Peripherals and Peripheral Interface, Instruction Set, Software Tools, Embedded C programming - Design of FIR & IIR filters - Harmonic Frequency Detection.

FOR FURTHER READING

DSP Based control of Permanent Magnet & Switched reluctance motor drives, Matrix converters, Vector control of Induction Motors.

Total: 45 Hours

Reference(s)

1. William Bolton, Programmable Logic Controllers, Elsevier, 2015.
2. Hamid Toliyat and Steven Campbell, DSP-Based Electromechanical Motion Control, CRC Press, 2011.
3. Wayne Wolf, FPGA based system design,Prentice hall, 2009.
4. J.R.Gibson, ARM Assembly language An Introduction, CENGAGE Learning, 2011.
5. Kenneth W. Evans, John Polywka, Stanley Gabrel, Programming of Computer Numerically Controlled Machines, Second Edition, Industrial Press, 2012.

21PE60 DISTRIBUTED GENERATION SYSTEMS 3 0 0 3

Course Objectives

- Illustrate the concept of distributed generations and its grid integration.
- Infer the impact of distributed generation in distribution system.
- Interpret the working of standalone and grid-connected renewable energy generation schemes.

Programme Outcomes (POs)

a. Apply the core knowledge to identify, formulate, and solve problems in Power Electronics and Drives systems.
b. Apply knowledge in mathematics, science, electric and electronic circuits to develop and analyze mathematical models for power electronic converters and controllers.
c. Design power electronic circuits for industrial and commercial applications with due consideration on public health, safety and environmental constraints with sustainability and ethical responsibility.

Course Outcomes (COs)

1. Apply the standards for integrating Distributed Generation (DG) and analyse the security issues in DG installation.
2. Analyse the integration methods of distributed generation with optimal selection of location and size.
3. Analyse the impact of DGs upon the voltage profile, reactive power flow, harmonics and stability issues in distribution system.
4. Analyse the energy economics of distributed resources and demand side management for DG scheduling.
5. Analyse the structure and configuration of AC and DC Micro grids with power electronic interfaces.

UNIT I **9 Hours**

DISTRIBUTED GENERATIONS

Distributed Generation Technology -Solar photovoltaic power - wind - fuel cells - Diesel Generator - Hydro and Micro turbines - Classification of DG - Standards for interconnecting Distributed resources to electric power systems: IEEE 1547 - DG installation classes, security issues in DG implementations.

UNIT II **9 Hours**

DG INTEGRATION IN DISTRIBUTION SYSTEM

Distribution Systems - Grid integration of DGs - site selection and sizing of DGs in distribution system- Optimal placement and sizing of DG sources in distribution systems - types of interfaces, Inverter based DGs interfaces.

UNIT III **9 Hours**

PERFORMANCE OF DISTRIBUTION SYSTEM WITH DG

Control aspects of DGs- Market facts. Impact of DGs, Voltage control techniques. Reactive power control, Harmonic issues, reliability of DG based systems, protective relaying - Steady-state and Dynamic analysis.

UNIT IV **9 Hours**

ECONOMICS OF DISTRIBUTED RESOURCES

Distributed Resources (DR) - Electric Utility Rate Structures- Energy Economics- Energy Conservation Supply Curves - Distributed Benefits- Integrated Resource Planning (IRP) and Demand-Side Management (DSM) - DG Scheduling - DG planning, cost implications of power quality, cost of energy and implications on power converter design.

UNIT V **9 Hours**

MICROGRIDS

Microgrid - Concept and Operation - Structure and configuration - Drivers - Mode of operation - Communication infrastructure - AC and DC microgrids - Micro-grids with power electronic interfacing units - Hybrid DG in microgrid

FOR FURTHER READING

Transients in micro-grids, Protection of micro-grids, Case studies, Introduction to smart microgrids.

Total: 45 Hours

Reference(s)

1. H. Lee Willis, Walter G. Scott, Distributed Power Generation - Planning and Evaluation, Marcel Decker Press, 2000.
2. M.Godoy Simoes, Felix A. Farret, Renewable Energy Systems - Design and Analysis with Induction Generators, CRC press, second edition, 2007.
3. Stuart Borlase, Smart Grid: Infrastructure Technology Solutions, CRC Press, 2012.
4. Gilbert M.Masters, Renewable and Efficient Electric Power Systems, John Wiley & Sons, Inc., Second edition, 2013.
5. Ned Mohan, Tore M. Undeland, William P. Robbins, Power Electronics: Converters, Applications, and Design, Wiley, Fourth edition, 2017.

21PE61 SMART GRID TECHNOLOGIES 3 0 0 3

Course Objectives

- Interpret the concepts of energy management system in smart grid.
- Design of real time power monitoring system in the grid.
- Illustrate the communication architecture of smart grid.

Programme Outcomes (POs)

a. Apply the core knowledge to identify, formulate, and solve problems in Power Electronics and Drives systems.
b. Apply knowledge in mathematics, science, electric and electronic circuits to develop and analyze mathematical models for power electronic converters and controllers.
c. Design power electronic circuits for industrial and commercial applications with due consideration on public health, safety and environmental constraints with sustainability and ethical responsibility.

Course Outcomes (COs)

1. Analyse the architecture models and the policies for implementation of smart grid.
2. Apply the concept of smart metering and smart substation for outage management in the distribution system.
3. Analyse various protection and control techniques for smart energy management system.
4. Apply the concept of communication protocol for the data transmission in smart grid.
5. Apply the concept of big data analytics and cyber security for data management and protection in smart grid.

UNIT I **9 Hours**

INTRODUCTION

Introduction to Smart Grid, Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Concept of Robust & Self-Healing Grid, Present development & Indian policies in Smart Grid, Smart Grid Architecture Models, Components of Smart Grid.

UNIT II **9 Hours**

SMART METERS AND SMART SUBSTATION

Smart Distribution Systems: Smart Meters, Automatic Meter Reading (AMR), Advanced Metering Infrastructure (AMI), Substation Automation, Feeder Automation, Outage Management System (OMS).Faults in the distribution system, Components for fault isolation and restoration, Fault location, isolation and restoration, Voltage regulation.

UNIT III **9 Hours**

ENERGY MANAGEMENT SYSTEM

Introduction-Data sources - Intelligent Electronic Devices (IED) & their application for Monitoring & Protection. Wide Area Monitoring Protection and Control (WAMPAC), Phasor Measurement Unit (PMU) and its applications in Smart Grid Energy management systems- Wide area applications -On-line transient stability controller, Pole-slipping preventive controller; Smart Appliances.

UNIT IV **9 Hours**

COMMUNICATION NETWORKS

Communication Architecture for Smart Grids, Home Area Network (HAN) : IEEE 802.11, IEEE 802.15.4, 6LoWPAN, Neighbourhood Area Network (NAN) / Field Area Network (FAN): Radio over Power-Lines (BPL/PLC), IEEE P1901, Wide Area Network (WAN) : Optical Fibre Communication, Cellular Networks, Wi-Max and Wireless Sensor Networks.

UNIT V **9 Hours**

BIG DATA ANALYTICS AND CYBER SECURITY FOR SMART GRID

Big Data Analytics in Smart Grid - Need of Data Analysis in Smart Grid, Data Science Pertaining to Smart Grid Analytics, Cyber Security Challenges in Smart Grid - Load Altering Attacks - False Data Injection Attacks - Defence Mechanisms.

FOR FURTHER READING

Load forecasting, Home & Building Automation, Plug in Hybrid Electric Vehicles (PHEV), Algorithms for Vehicle to Grid and Grid to Vehicle Management, Smart Charging Stations.

Total: 45 Hours

Reference(s)

1. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu and Akihiko Yokoyama, Smart Grid: Technology and Applications, Wiley, 2012.
2. Xiao, Security and Privacy in Smart Grids, CRC Press, New York, 2014.
3. Ali Keyhani, Design of Smart Power Grid Renewable Energy Systems, Wiley, 2016.
4. James Momoh, SMART GRID: Fundamentals of Design and Analysis, John Wiley and Sons, New York, 2012.
5. Yang Xiao, Communication and Networking in Smart Grids, Taylor and Francis, New Delhi,2012.

21PE62 HVDC SYSTEMS 3 0 0 3

Course Objectives

- Interpret the Faults and protections, Harmonics and Filters in HVDC systems.
- Summarize the properties and control of power electronic converters for HVDC transmission systems.
- Analyze the Reactive power control and Power factor improvements of the systems.

Programme Outcomes (POs)

a. Apply the core knowledge to identify, formulate, and solve problems in Power Electronics and Drives systems.
b. Apply knowledge in mathematics, science, electric and electronic circuits to develop and analyze mathematical models for power electronic converters and controllers.
c. Design power electronic circuits for industrial and commercial applications with due consideration on public health, safety and environmental constraints with sustainability and ethical responsibility.

Course Outcomes (COs)

1. Analyze the structure of HVDC transmission system with economic considerations.
2. Analyze the characteristics of different power converters and select suitable converters for HVDC transmission system.
3. Apply the various control techniques for power converters and analyze the effect of source inductance in HVDC system.
4. Analyze the fault occurrences and apply the suitable protection schemes in HVDC transmission system.
5. Analyze the effects of harmonics in HVDC system and design a suitable filter for harmonic mitigation.

UNIT I **9 Hours**

INTRODUCTION

Introduction of DC Power transmission technology - Comparison of AC and DC transmission - Application of DC transmission - Structure of HVDC transmission system - Reactive power demand-Economic considerations - Modern trends in DC transmission.

UNIT II **9 Hours**

ANALYSIS OF HVDC CONVERTERS

Pulse number converters - Choice of converter configuration - Properties of Thyristor converter circuits - Three phase converters - Simplified analysis of Graetz circuit with and without overlaps - Characteristics of a twelve pulse converter -Transformer connections.

UNIT III **9 Hours**

CONTROL OF CONVERTERS

Principal of DC Link Control - Basic means of control - Gate Control - Power reversal Constant current versus constant voltage- Converters Control Characteristics - Firing angle control - Current and extinction angle control- Frequency control - Effect of source inductance on the system Starting and stopping of DC link- Power Control.

UNIT IV **9 Hours**

FAULTS IN CONVERTERS AND ITS PROTECTION

Converter disturbance - By pass action in bridge- Short circuit on a rectifier - Commutation failure- Basics of protection - DC reactors - Voltage and current oscillations - Clearing line faults and re-energizing - Circuit breakers - Overvoltage protection.

UNIT V **9 Hours**

HARMONICS AND FILTERS

Introduction - Generation of harmonics - Effects of harmonics and its mitigation-Design of AC filters and DC filters - Corona loss in HVDC lines - Radio interference due to corona Grounding - advantages and problems.

FOR FURTHER READING

Modern trends in thyristor valves - Deciding factors for best circuit of HVDC converters - Shut capacitors - Shynchronous condensers - Surge arresters - Design of earth electrodes

Total: 45 Hours

Reference(s)

1. Padiyar K.R., HVDC Power Transmission System /direct current, New Academic Science,2011.
2. Dragan Jovcic, Khaled Ahmed High Voltage Direct Current Transmission, John Wiley & Sons, 2015.
3. Arrillaga J, Liu Y.H, Watson NR, Flexible Power Transmission: The HVDC Options, John-Wiley & Sons INC publication, 2010.
4. Rakosh Das Begamudre, Extra High Voltage AC Transmission Engineering, New Age International (P) Ltd, New Delhi,2011.
5. Vijay K Sood, HVDC and FACT Controllers: Application of Static Converter in Power Systems, Kluwer Academic Publication, 2006.

21PE63 AUTOMOTIVE ELECTRONICS 3 0 0 3

Course Objectives

- Interpret the internal structure, the switching and operating characteristics of the basic power devices.
- Summarize the advanced sensor and its working principle.
- Recognize the various advanced safety systems in automobile.

Programme Outcomes (POs)

a. Apply the core knowledge to identify, formulate, and solve problems in Power Electronics and Drives systems.
c. Design power electronic circuits for industrial and commercial applications with due consideration on public health, safety and environmental constraints with sustainability and ethical responsibility.
e. Attain proficiency in Communication and to work in multidisciplinary team as an individual or leader in Power Electronics and Drives industries.
f. Engage in lifelong learning, plan and conduct a systematic study on significant research with effective utilization of resources.

Course Outcomes (COs)

1. Analyze the characteristics of electronic devices used in Ignition system.
2. Analyze the control system used in Hybrid vehicles and calculate the net emission mobility for EV.
3. Apply the various communication protocols and analyze the performance of Electric Vehicles.
4. Apply the characteristics of different sensors and actuators in designing electric vehicles.
5. Analyze the functions of different safety systems for autonomous electric vehicles.

UNIT I **9 Hours**

IGNITION SYSTEMS

Ignition Systems: Types, Construction &working of battery coil and Magneto ignition systems.Relative merits, Centrifugal and vacuum advance mechanisms, types and construction of spark plugs, electronic ignition systems, Electronic fuel Control.

UNIT II **9 Hours**

E-MOBILITY

Basic principles and trends of smart mobility, concept of e-mobility, last-mile and first-mile connectivity, connected vehicles, EVs-Well to Wheel Analysis, power generation mix in India, emissions from power generation, net emission calculations for EVs; Drive cycle analysis, driving pattern of various vehicles, Control systems used in HEVs and EVs, supervisory control of vehicles, speed and torque control in EVs, rule-based and optimization-based controllers used in EVs.

UNIT III **9 Hours**

ELECTRIC PROPULSION AND COMMUNICATION PROTOCOLS

Introduction to electric components used in electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, Configuration and control of Permanent Magnet Motor drives. Communication protocols: Overview of automotive communication protocols, CAN, LIN , Flex Ray, MOST , Ethernet, D2B and DSI, Communication interface with ECUs

UNIT IV **9 Hours**

SENSORS AND ACTUATORS

Airflow rate sensor, Strain Gauge MAP sensor, Engine Crankshaft Angular Position Sensor, Magnetic Reluctance Position Sensor, Hall effect Position Sensor, Shielded Field Sensor, Optical Crankshaft Position Sensor, Throttle Angle Sensor (TAS), Engine Coolant Temperature (ECT) Sensor, Exhaust Gas Oxygen (O2/EGO) Lambda Sensors, Piezoelectric Knock Sensor.Solenoid, Fuel Injector, EGR Actuator, Ignition System

UNIT V **9 Hours**

SAFETY SYSTEMS IN AUTOMOBILES

Active Safety Systems: ABS, TCS, ESP, Brake assist, etc. Passive Safety Systems: Airbag systems, Advanced Driver Assistance Systems (ADAS): Combining computer vision techniques as pattern recognition, feature extraction, learning, tracking, 3D vision, etc. to develop real-time algorithms able to assist the driving activity. Examples of Assistance Applications: Lane Departure Warning, Collision Warning, Automatic Cruise Control, Pedestrian Protection, Headlights Control, Connected Cars technology and trends towards Autonomous vehicles.

FOR FURTHER READING

Current trends in automotive electronic engine management system, electromagnetic interference suppression, electromagnetic compatibility, electronic dashboard instruments, on board diagnostic system, security and warning system.

Total: 45 Hours

Reference(s)

1. Williams. B. Ribbens: Understanding Automotive Electronics, 6th Edition, Elsevier Science, Newnes Publication, 2019.
2. Robert Bosch: Automotive Electronics Handbook, John Wiley and Sons, 2018.
3. Tracy Martin: How to Diagnose and Repair Automotive Electrical Systems, Motor Books / MBl Publishing Company, 2015.
4. Iqbal Husain: Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2016.
5. Tom Denton: Advanced Automotive Diagnosis, 5th Edition, Elsevier, 2018.

21PE64 OPTIMIZATION TECHNIQUES 3 0 0 3

Course Objectives

- Interpret about the various optimization techniques.
- Interpret constrained and unconstrained optimization techniques to solve an electrical circuit design problem in real world situation.
- Summarize the concept of geometric, integer, dynamic programming and modern methods of optimization techniques for project implementation.

Programme Outcomes (POs)

a. Apply the core knowledge to identify, formulate, and solve problems in Power Electronics and Drives systems.
b. Apply knowledge in mathematics, science, electric and electronic circuits to develop and analyze mathematical models for power electronic converters and controllers.
c. Design power electronic circuits for industrial and commercial applications with due consideration on public health, safety and environmental constraints with sustainability and ethical responsibility.
d. Select and apply appropriate tools for modeling, simulation and analysis of power electronics circuits for renewable energy applications.

Course Outcomes (COs)

1. Analyze the classical optimization techniques and to model optimization problems based on engineering minima/maxima conditions.
2. Analyze the different linear programming methods and apply the solutions of degeneracy for transportation problems.
3. Evaluate the types of Non-Linear programming methods and design quadratic solutions for real world problems.
4. Analyze the integer and dynamic programming and apply different optimization techniques to solve various problems arising from engineering areas.
5. Apply the computational methods and implement the optimization algorithm using MATLAB to solve the problems.

UNIT I **9 Hours**

INTRODUCTION TO OPTIMIZATION

Engineering Applications - Classification of optimization problems - Concept of system & state and its characteristics - Classical optimization techniques - Single and multivariable optimization with and without constraints - Lagrange model - Kuhn - tucker conditions

UNIT II **9 Hours**

LINEAR PROGRAMMING

Standard form of LPP - Solution of a system of linear simultaneous equations - Linear optimization algorithms: simplex method - Computer implementation of simplex method - Gauss Jordan Elimination process - Dual linear programs - applications. Transportation problems- Basic solution of degeneracy.

UNIT III **9 Hours**

NON LINEAR PROGRAMMING

Nonlinear programming - One dimensional minimization methods - Cubic method unconstrained optimization techniques - Direct search method - Steepest Descent method - Constrained optimization techniques - Transformation techniques -Solution of quadratic programming problems using KKT necessary condition.

UNIT IV **9 Hours**

GEOMETRIC , INTEGER PROGRAMMING AND DYNAMIC PROGRAMMING

Geometric programming - Unconstrained minimization problem - Constrained minimization problem -Geometric programming with mixed inequality constraints - Integer programming -Dynamic programming - Conversion of a final value problem into an initial value problem. Practical aspects of optimization - sensitivity of optimum solution to problem parameters.

UNIT V **9 Hours**

MODERN METHODS OF OPTIMIZATION TECHNIQUES

Genetic algorithm - Ant colony optimization - Particle swarm optimization - Neural network based optimization. Wind/Solar PV integrated systems - Optimization of system components - Applications

FOR FURTHER READING

Stochastic Programming - Separable programming and Fuzzy based optimization

Total: 45 Hours

Reference(s)

1. Donald A. Pierre, Optimization Theory with Applications, Courier Corporation, 2012.
2. K Anoune, M Bouya, A Astito, AB Abdellah , Sizing methods and optimization techniques for PV-wind based hybrid renewable energy system, Renewable and Sustainable, Elsevier,2018.
3. C Gamarra , JM Guerrero, Computational optimization techniques applied to microgrids planning: A review Renewable and Sustainable Energy Reviews, Elsevier, 2015.
4. Hamdy A.Taha., Programming: Theory, Applications and Computations, Academic Press, 2014.
5. Computer based optimization techniques, Oxford, U.K. Alpha Science International Ltd, 2015.

21PE65 ELECTRICAL ENERGY CONSERVATION AND MANAGEMENT

3 0 0 3

Course Objectives

- To outline the importance of energy conservation and management system.
- To assess the energy conservation opportunities in electro mechanical equipment's.
- To integrate the demand side management system in electrical utilities.

Programme Outcomes (POs)

a. Apply the core knowledge to identify, formulate, and solve problems in Power Electronics and Drives systems.
b. Apply knowledge in mathematics, science, electric and electronic circuits to develop and analyze mathematical models for power electronic converters and controllers.
c. Design power electronic circuits for industrial and commercial applications with due consideration on public health, safety and environmental constraints with sustainability and ethical responsibility.
e. Attain proficiency in Communication and to work in multidisciplinary team as an individual or leader in Power Electronics and Drives industries.

Course Outcomes (COs)

1. Analyze the various energy conservation schemes and apply energy conservation act for electrical systems.
2. Analyze the factors affecting the performance of electrical systems and improve the performance using energy conservation techniques.
3. Apply the suitable energy audit technique and tools to maximize the efficacy of electrical system.
4. Analyze the different financial management techniques in energy management system for system optimization.
5. Evaluate the demand side management and barriers in electrical system for cost reduction.

UNIT I **9 Hours**

ENERGY SCENARIO

Energy Scenario- Role of energy Managers in Industries- Energy monitoring, auditing and targeting-Economics of various energy conservation schemes -Total energy systems-Energy conservation and its importance- Energy conservation Act 2001 and its features

UNIT II **9 Hours**

ELECTRICAL ENERGY CONSERVATION

Energy Efficiency Improvement in Electrical Systems- -Electrical load management, maximum demand control- Power factor correction- Electric Motors efficiency, factors affecting motor performance- energy efficient motors- Transformers- lighting-case studies

UNIT III **9 Hours**

ENERGY MANAGEMENT

Definition, energy audit, need, types of energy audit. Energy management (audit) approaches- understanding energy costs- Benchmarking, energy performance, matching energy use to requirement, maximizing system efficiencies, fuel and energy substitution, energy audit instruments and metering.

UNIT IV **9 Hours**

FINANCIAL MANAGEMENT

Energy Economics - Simple Payback Period, Time Value of Money, IRR, NPV, Life Cycle Costing, Cost of Saved Energy, Cost of Energy generated, Examples from energy generation and conservation- risk and sensitivity analysis

UNIT V **9 Hours**

ENERGY EFFICIENCY AND DEMAND SIDE MANAGEMENT

Basic concepts -Importance of demand side managements- Efficiency gains -Estimation of energy efficiency potential -Cost effectiveness- Barriers for energy efficiency and Demand Side Management.

FURTHER READING

Energy Audit case studies - Sugar, Steel, Cement, Paper Industries

Total: 45 Hours

Reference(s)

1. Thomas Johansson, A K N Reddy, Robert Williams, Energy for a sustainable world, Wiley Eastern ,2000.
2. Albert Thumann, Terry Niehus, Handbook of Energy Audits, 2012.
3. Charles E Brown, World Energy Resources, Springer, 2012.
4. Amlan Chakrabarti, Energy Engineering and Management, Prentice hall India, 2011.
5. BEE reference book,1/2/3/4.

21PE66 DSP BASED SYSTEM DESIGN 3 0 0 3

Course Objectives

- To understand the signals and systems and their mathematical representation in time/frequency domain.
- To understand the architectural overview and addressing modes in DSC controllers.
- Develop enough confidence to identify and model programs in real world and offer appropriate solutions, using the skills learned in their interactive and supporting environment.

Programme Outcomes (POs)

b. Apply knowledge in mathematics, science, electric and electronic circuits to develop and analyze mathematical models for power electronic converters and controllers.
c. Design power electronic circuits for industrial and commercial applications with due consideration on public health, safety and environmental constraints with sustainability and ethical responsibility.
e. Attain proficiency in Communication and to work in multidisciplinary team as an individual or leader in Power Electronics and Drives industries.
f. Engage in lifelong learning, plan and conduct a systematic study on significant research with effective utilization of resources.

Course Outcomes (COs)

1. Analyse the performance of various algorithm and design a suitable filter signal processing.
2. Apply programming methods and features of Digital Signal Controllers for real time applications.
3. Attain proficiency in Communication and to work in multidisciplinary team as an individual or leader in Power Electronics and Drives oriented industries.
4. Analyse the performance of Digital Signal controllers and select suitable controller for Industrial applications.
5. Apply Code Composer Studio IDE to develop an algorithm using for real time signal processing applications.

UNIT I **9 Hours**

DSP INTRODUCTION

Classification of Signals and Systems - Computation of DFT using FFT algorithms, DIT and DIF-Computation of DFT using FFT algorithm - DIT & DIF using radix 2 FFT - Butterfly structure - Design of Digital Filters, FIR and IIR Filters.

UNIT II **9 Hours**

DIGITAL SIGNAL CONTROLLER - C2000

Architecture Overview- Memory Organization-Fixed Point - Floating Point, Peripheral Register Programming - I/O Ports- Timer peripherals - Control Peripherals - Direct Memory Access - System Design.

UNIT III **9 Hours**

PERIPHERALS OF SIGNAL PROCESSORS

Peripherals Types, Memory Space Organization, External Bus Interfacing Signals, Memory Interface, Parallel I/O Interface, Synchronous Serial Interface - A/D converter -D/A Converter -Event Managers (EVA, EVB) - PWM signal generation control.

UNIT IV **9 Hours**

APPLICATIONS OF DIGITAL SIGNAL CONTROLLER

Voltage regulation of DC/DC power conversion- Stepper motor and DC motor control -Charging stations (AC/DC)-Onboard charging for electric vehicle - Implementation of Solar Power Charging control.

UNIT V **9 Hours**

DEVELOPMENT TOOLS AND CASE STUDY

DSP Development Tools - The Digital Signal Controller Kit (DSC) - The Assembler and the Assembly Source File - The Linker and Memory Allocation - The Code Composer Studio (CCS) - Power quality monitoring system- Digital Signal Processing Library Development Enables Effective Processor Deployments.

FOR FURTHER READING

Digital Signal Processor, Digital Signal Controller, Analog and Digital Peripherals.

Total: 45 Hours

Reference(s)

1. Richard G. Lyons, Understanding Digital Signal Processing, Prentice Hall, 3rd Edition, 2015.
2. S. Salivahanan, A.Vallavaraj, Gnanapriya, Digital Signal Processing, McGraw-Hill, 2nd Edition, 2016.
3. C.Rafeal Gonzalez and E.Richard Woods, Digital Image Processing, Fourth Edition, Pearson Education 2018.
4. John B.Peatman , Design with PIC Microcontrollers , Pearson Education, Asia 2018.
5. Hamid A.Toliyat, Steven Campbell, DSP based electromechanical motion control ,CRC Press 2019.

21XE01 ENGLISH FOR RESEARCH PAPER WRITING

2 0 0 0

Course Objectives

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

Programme Outcomes (POs)

e. Attain proficiency in Communication and to work in multidisciplinary team as an individual or leader in Power Electronics and Drives industries.
f. Engage in lifelong learning, plan and conduct a systematic study on significant research with effective utilization of resources.

Course Outcomes (COs)

1. Illustrate the research ideas and writing journal papers
2. Creating research paper writing

UNIT I **5 Hours**

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness.

UNIT II **5 Hours**

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction

UNIT III **5 Hours**

Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.

UNIT IV **5 Hours**

Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature.

UNIT V **5 Hours**

Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions.

UNIT VI **5 Hours**

Useful phrases, how to ensure paper is as good as it could possibly be the first- time submission.

Total: 30 Hours

Reference(s)

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books).
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press.
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highmans book.
4. Adrian Wallwork, English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011.

21XE02 COST MANAGEMENT OF ENGINEERING PROJECTS **2 0 0 0**

Course Objectives

- To understand the cost concepts and different stages of project execution and its activities.
- To understand cost behavior, management and its quantitative techniques.

Programme Outcomes (POs)

c. Design power electronic circuits for industrial and commercial applications with due consideration on public health, safety and environmental constraints with sustainability and ethical responsibility.
e. Attain proficiency in Communication and to work in multidisciplinary team as an individual or leader in Power Electronics and Drives industries.
f. Engage in lifelong learning, plan and conduct a systematic study on significant research with effective utilization of resources.

Course Outcomes (COs)

1. Apply the cost concepts in decision making.
2. Analyze the various stages of project execution and its activities.
3. Analyze the cost behavior and various types of costing.
4. Analyze the cost management and budget related decisions.
5. Analyze the quantitative techniques for cost management.

UNIT I **6 Hours**

COST CONCEPTS IN DECISION-MAKING

Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

UNIT II **6 Hours**

PROJECT

Meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process.

UNIT III **6 Hours**

COST BEHAVIOR AND PROFIT PLANNING MARGINAL COSTING

Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning.

UNIT IV **6 Hours**

TOTAL QUALITY MANAGEMENT AND THEORY OF CONSTRAINTS

Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

UNIT V **6 Hours**

QUANTITATIVE TECHNIQUES FOR COST MANAGEMENT

Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

Total: 30 Hours

Reference(s)

1. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi.
2. Charles T. Horngren and George Foster, Advanced Management Accounting.
3. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting.
4. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher.
5. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

21XE03 STRESS MANAGEMENT 2 0 0 0

Course Objectives

- To achieve overall health of body and mind.
- To overcome stress by practicing yoga.

Programme Outcomes (POs)

f. Engage in lifelong learning, plan and conduct a systematic study on significant research with effective utilization of resources.

Course Outcomes (COs)

1. Develop healthy mind in a healthy body thus improving social health also.
2. Improve Efficiency of the body by practicing breathing exercises and yoga.

UNIT I **10 Hours**

Definitions of Eight parts of yoga. (Ashtanga)

UNIT II **10 Hours**

Yam and Niyam. Dos and Donts in life.i) Ahinsa, satya, astheya, bramhacharya and aparigraha, ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan.

UNIT III **10 Hours**

Asan and Pranayam, i) Various yog poses and their benefits for mind & body ii) Regularization of breathing techniques and its effects-Types of pranayam.

Total: 30 Hours

Reference(s)

1. Yogic Asanas for Group Training-Part-I Janardan Swami Yogabhyasi Mandal, Nagpur. Model Curriculum of Engineering & Technology PG Courses [Volume-I][47].
2. Rajayoga or conquering the Internal Nature by Swami Vivekananda, AdvaitaAshrama (Publication Department), Kolkata.

21XE04 DISASTER MANAGEMENT 2 0 0 0

Course Objectives

- Learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations
- Critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in

Programme Outcomes (POs)

c. Design power electronic circuits for industrial and commercial applications with due consideration on public health, safety and environmental constraints with sustainability and ethical responsibility.
f. Engage in lifelong learning, plan and conduct a systematic study on significant research with effective utilization of resources.

Course Outcomes (COs)

1. Illustrate the key concepts in disaster risk reduction and humanitarian response
2. Interpret the strengths and weaknesses of disaster management approaches, planning and programming

UNIT I **5 Hours**

INTRODUCTION

Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude.

UNIT II **5 Hours**

REPERCUSSIONS OF DISASTERS AND HAZARDS

Economic Damage, Loss of Human and Animal Life, Destruction of Ecosystem. Natural Disasters: Earthquakes, Volcanisms and Cyclones, Tsunamis and Floods, Droughts and Famines, Landslides and Avalanches Man-made disaster Nuclear Reactor Meltdown, Industrial Accidents and Oil Slicks and Spills Outbreaks of Disease and Epidemics War and Conflicts.

UNIT III **5 Hours**

DISASTER PRONE AREAS IN INDIA

Study of Seismic Zones; Areas Prone to Floods and Droughts, Landslides and Avalanches; Areas Prone to Cyclonic and Coastal Hazards with Special Reference to Tsunami; Post-Disaster Diseases and Epidemics

UNIT IV **5 Hours**

DISASTER PREPAREDNESS AND MANAGEMENT

Preparedness: Monitoring of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological and other Agencies, Media Reports: Governmental and Community Preparedness.

UNIT V **5 Hours**

RISK ASSESSMENT

Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival.

UNIT VI **5 Hours**

DISASTER MITIGATION

Disaster Mitigation Meaning, Concept and Strategies of Disaster Mitigation, Emerging Trends in Mitigation. Structural Mitigation and Non-Structural Mitigation, Programs of Disaster Mitigation in India.

Total: 30 Hours

Reference(s)

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies " , New Royal book Company.
2. Sahni, Pardeep Et.Al. (Eds.)," Disaster Mitigation Experiences and Reflections", Prentice Hall of India, New Delhi.
3. Goel S. L. "Disaster Administration and Management Text and Case Studies", Deep &Deep Publication Pvt. Ltd., New Delhi.
4. Model Curriculum of Engineering & Technology PG Courses [Volume-I] [42].

21XE05 VALUE EDUCATION 2 0 0 0

Course Objectives

- Interpret value of education and self- development
- Imbibe good values in students
- Let the should know about the importance of character

Programme Outcomes (POs)

e. Attain proficiency in Communication and to work in multidisciplinary team as an individual or leader in Power Electronics and Drives industries.
f. Engage in lifelong learning, plan and conduct a systematic study on significant research with effective utilization of resources.

Course Outcomes (COs)

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

UNIT I **8 Hours**

Values and self-development- Social values and individual attitudes -Work ethics- Indian vision of humanism- Moral and non- moral valuation-Standards and principles-Value judgements.

UNIT II **7 Hours**

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

UNIT III **8 Hours**

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

UNIT IV **7 Hours**

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

Total: 30 Hours

Reference(s)

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

21XE06 PEDAGOGY STUDIES 2 0 0 0

Course Objectives

- Review existing evidence on the review topic to inform programmer design and policy making undertaken by the DfID, other agencies and researchers
- Identify critical evidence gaps to guide the development.

Programme Outcomes (POs)

f. Engage in lifelong learning, plan and conduct a systematic study on significant research with effective utilization of resources.

Course Outcomes (COs)

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

UNIT I **8 Hours**

INTRODUCTION AND METHODOLOGY

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

UNIT II **7 Hours**

THEMATIC OVERVIEW

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

UNIT III **8 Hours**

EVIDENCE ON THE EFFECTIVENESS OF PEDAGOGICAL PRACTICES

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

UNIT IV **7 Hours**

PROFESSIONAL DEVELOPMENT

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

Total: 30 Hours

Reference(s)

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379.
3. Akyeampong K (2003) Teacher training in Ghana - does it count. Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272-282.
5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. Chavan M (2003) Read India: A mass scale, rapid, "learning to read" campaign.

21XE07 BUSINESS ANALYTICS 2 0 0 0

Course Objectives

- Illustrate the role of business analytics within an organization
- Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization
- To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making
- To become familiar with processes needed to develop, report, and analyze business data
- Use decision-making tools/Operations research techniques and Manage business process using analytical and management tools

Programme Outcomes (POs)

b. Apply knowledge in mathematics, science, electric and electronic circuits to develop and analyze mathematical models for power electronic converters and controllers.
d. Select and apply appropriate tools for modeling, simulation and analysis of power electronics circuits for renewable energy applications.
f. Engage in lifelong learning, plan and conduct a systematic study on significant research with effective utilization of resources.

Course Outcomes (COs)

1. Implement the knowledge of data analytics
2. Apply the ability of think critically in making decisions based on data and deep analytics.
3. Analyze the ability to use technical skills in predicative and prescriptive modeling to support business decision-making
4. Determine the ability to translate data into clear, actionable insights
5. Analyze the decision problems in business analytics

UNIT I **6 Hours**

BUSINESS ANALYTICS AND STATISTICAL TOOLS

Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics-Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview

UNIT II **6 Hours**

TRENDINESS AND REGRESSION ANALYSIS

Modelling Relationships and Trends in Data, simple Linear Regression. Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology

UNIT III **6 Hours**

ORGANIZATION STRUCTURES OF BUSINESS ANALYTICS

Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes. Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization

UNIT IV **6 Hours**

FORECATING TECHNIQUES

Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models

UNIT V **6 Hours**

DECISION ANALYSIS

Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making

Total: 30 Hours

Reference(s)

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education.