KONGU ENGINEERING COLLEGE

(Autonomous Institution Affiliated to Anna University, Chennai)

PERUNDURAI ERODE – 638 060

TAMILNADU INDIA

Estd : 1984

REGULATIONS, CURRICULUM & SYLLABI - 2020

(CHOICE BASED CREDIT SYSTEM AND
OUTCOME BASED EDUCATION)
(For the students admitted during 2020 - 2021 and onwards)

MASTER OF DEGREE
IN
POWER ELECTRONICS AND DRIVES

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

KONGU
Assuring the Best

INDEX

KONGU ENGINEERING COLLEGE
PERUNDURAI ERODE – 638 060
(Autonomous)

INSTITUTE VISION

To be a centre of excellence for development and dissemination of knowledge in Applied Sciences, Technology, Engineering and Management for the Nation and beyond.

INSTITUTE MISSION

We are committed to value based Education, Research and Consultancy in Engineering and Management and to bring out technically competent, ethically strong and quality professionals to keep our Nation ahead in the competitive knowledge intensive world.

QUALITY POLICY

We are committed to

- Provide value based quality education for the development of students as competent and responsible citizens.
- Contribute to the nation and beyond through research and development
- Continuously improve our services

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

VISION

To be a centre of excellence for development and dissemination of knowledge in Electrical and Electronics Engineering to benefit the society in the National and global level.

MISSION

Department of Electrical and Electronics Engineering is committed to:

MS1:	Develop innovative, competent, ethical and quality engineers to contribute for technical advancements to meet societal needs..
MS2:	Provide state-of-the-art facilities for continual improvement in teaching-learning process and research activities.
MS3:	Enrich the knowledge and skill of the students to cater to the industrial needs and motivate them to become entrepreneurs.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

Post Graduates of Electrical and Electronics Engineering will

PEO1:	Utilize fundamental knowledge of power electronics and drives to succeed in professional and research career.
PEO2:	Design, simulate, analyze and develop power electronic and electrical drive based products which are reliable, cost effective and safe.
PEO3:	Apply the power electronic applications to electrical system and thereby improve the performance parameters using conventional and advanced control techniques.

MAPPING OF MISSION STATEMENTS (MS) WITH PEOs

MS\PEO	PEO1	PEO2	PEO3
MS1	2	3	3
MS2	2	3	3
MS3	3	3	3

1 – Slight, 2 – Moderate, 3 – Substantial

PROGRAM OUTCOMES (POs)	
M.E (Power Electronics and Drives) Graduates will be able to:	
PO1:	An ability to independently carry out research /investigation and development work to solve practical problems
PO2:	An ability to write and present a substantial technical report/document
PO3:	An ability to demonstrate a degree of mastery over the area of Power Electronics and Drives.

MAPPING OF PEOs WITH POs

PEO\PO	PO1	PO2	PO3
PEO1	3	2	3
PEO2	3	2	3
PEO3	3	3	3

1 – Slight, 2 – Moderate, 3 – Substantial

KONGU ENGINEERING COLLEGE, PERUNDURAI, ERODE – 638060

(An Autonomous Institution Affiliated to Anna University)

REGULATIONS 2020

CHOICE BASED CREDIT SYSTEM AND OUTCOME BASED EDUCATION

MASTER OF ENGINEERING (ME) / MASTER OF TECHNOLOGY (MTech) DEGREE PROGRAMMES

These regulations are applicable to all candidates admitted into ME/MTech Degree programmes from the academic year 2020 – 2021 onwards.

1. DEFINITIONS AND NOMENCLATURE

In these Regulations, unless otherwise specified:

i. "University" means ANNA UNIVERSITY, Chennai.

ii. "College" means KONGU ENGINEERING COLLEGE.

iii. "Programme" means Master of Engineering (ME) / Master of Technology (MTech) Degree programme

iv. "Branch" means specialization or discipline of ME/MTech Degree programme, like Construction Engineering and Management, Information Technology, etc.

v. "Course" means a Theory / Theory cum Practical / Practical course that is normally studied in a semester like Engineering Design Methodology, Machine Learning Techniques, etc.

vi. "Credit" means a numerical value allocated to each course to describe the candidate's workload required per week.

vii. "Grade" means the letter grade assigned to each course based on the marks range specified.

viii. "Grade point" means a numerical value (0 to 10) allocated based on the grade assigned to each course.

ix. "Principal" means Chairman, Academic Council of the College.

x. "Controller of Examinations" means authorized person who is responsible for all examination related activities of the College.

xi. "Head of the Department" means Head of the Department concerned of the College.

2. PROGRAMMES AND BRANCHES OF STUDY

The following programmes and branches of study approved by Anna University, Chennai and All India Council for Technical Education, New Delhi are offered by the College.

Programme	Branch
ME	Construction Engineering and Management
	Structural Engineering
	Engineering Design
	Mechatronics Engineering
	VLSI Design
	Embedded Systems
	Power Electronics and Drives
	Control and Instrumentation Engineering
	Computer Science and Engineering
MTech	Information Technology
	Chemical Engineering
	Food Technology

3. ADMISSION REQUIREMENTS

Candidates seeking admission to the first semester of the ME/MTech Degree programme shall be required to have passed an appropriate qualifying Degree Examination of Anna University or any examination of any other University or authority accepted by the Anna University, Chennai as equivalent thereto, subject to amendments as may be made by the Anna University, Chennai from time to time. The candidates shall also be required to satisfy all other conditions of admission prescribed by the Anna University, Chennai and Directorate of Technical Education, Chennai from time to time.

4. STRUCTURE OF PROGRAMMES

4.1 Categorisation of Courses

The ME / MTech programme shall have a curriculum with syllabi comprising of theory, theory cum practical, practical courses in each semester and project work, internship,etc that have been approved by the respective Board of Studies and Academic Council of the College. All the programmes have well defined Programme Outcomes (PO) and Programme Educational Objectives (PEOs) as per Outcome Based Education (OBE). The content of each course is designed based on the Course Outcomes (CO). The courses shall be categorized as follows:

i. Foundation Courses (FC)

ii. Professional Core (PC) Courses

iii. Professional Elective (PE) Courses

iv. Open Elective (OE) Courses

v. Employability Enhancement Courses (EC) like Innovative Project, Internship cum Project work in Industry or elsewhere, Project Work

4.2 Credit Assignment

Each course is assigned certain number of credits as follows:

Contact period per week	Credits
1 Lecture / Tutorial Period	1
2 Practical Periods	1
2 Project Work Periods	1
40 Training /Internship Periods	1

The minimum number of credits to complete the ME/MTech programme is 72.

4.3 Employability Enhancement Courses

A candidate shall be offered with the employability enhancement courses like innovative project, internship cum project work and project work during the programme to gain/exhibit the knowledge/skills.

4.3.1 Innovative Project

A candidate shall earn two credits by successfully completing the project by using his/her innovations in second semester during his/her programme.

4.3.2 Internship cum Project Work

The curriculum enables a candidate to go for full time internship during the third semester and can earn credits through it for his/her academics vide clause 7.6 and clause 7.12. Such candidate shall earn the minimum number of credits as mentioned in the third semester of the curriculum other than internship by either fast track mode or through approved courses in online mode or by self study mode. Such candidate can earn the number of credits for the internship same as that of Project Work in the third semester. Assessment procedure is to be followed as specified in the guidelines approved by the Academic Council.

4.3.4 Project Work

A candidate shall earn nine credits by successfully completing the project work in fourth semester during the programme inside the campus or in industries.

4.4 Value Added Courses / Online Courses / Self Study Courses

The candidates may optionally undergo Value Added Courses / Online Courses / Self Study Courses as elective courses.

4.4.1 **Value Added Courses:** Value Added courses each with One / Two credits shall be offered by the college with the prior approval from respective Board of Studies. A candidate can earn a maximum of three credits through value added courses during the entire duration of the programme.

4.4.2 **Online Courses:** Candidates may be permitted to earn credits for online courses, offered by NPTEL / SWAYAM / a University / Other Agencies, approved by respective Board of Studies.

4.4.3 **Self Study Courses:** The Department may offer an elective course as a self study course. The syllabus of the course shall be approved by the respective Board of Studies. However, mode of assessment for a self study course will be the same as that used for other courses. The candidates shall study such courses on their own under the guidance of member of the faculty. Self study course is limited to one per semester.

4.4.4 The elective courses in the final year may be exempted if a candidate earns the required credits vide clause 4.4.1, 4.4.2 and 4.4.3 by registering the required number of courses in advance (up to second semester).

4.4.5 A candidate can earn a maximum of 15 credits through all value added courses, online courses and self study courses.

4.5 Flexibility to Add or Drop Courses

4.5.1 A candidate 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 the candidate wishes, then the candidate is permitted to earn more than the total number of credits prescribed in the curriculum of the candidate's programme.

4.5.2 From the second to fourth semesters the candidates have the option of registering for additional elective/Honors courses or dropping of already registered additional elective/Honors courses within two weeks from the start of the semester. Add / Drop is only an option given to the candidates. Total number of credits of such courses during the entire programme of study cannot exceed six.

4.6 Maximum number of credits the candidate can enroll in a particular semester cannot exceed 30 credits.

4.7 The blend of different courses shall be so designed that the candidate at the end of the programme would have been trained not only in his / her relevant professional field but also would have developed to become a socially conscious human being.

4.8 The medium of instruction, examinations and project report shall be English.

5. DURATION OF THE PROGRAMME

5.1 A candidate is normally expected to complete the ME / MTech Degree programme in 4 consecutive semesters (2 Years), but in any case not more than 8 semesters (4 Years).

5.2 Each semester shall consist of a minimum of 90 working days including continuous assessment test period. The Head of the Department shall ensure that every teacher imparts instruction as per the number of periods specified in the syllabus for the course being taught.

5.3 The total duration for completion of the programme reckoned from the commencement of the first semester to which the candidate was admitted shall not exceed the maximum duration specified in clause 5.1 irrespective of the period of break of study (vide clause 11) or prevention (vide clause 9) in order that the candidate may be eligible for the award of the degree (vide clause 16). Extension beyond the prescribed period shall not be permitted.

6. COURSE REGISTRATION FOR THE EXAMINATION

6.1 Registration for the end semester examination is mandatory for courses in the current semester as well as for the arrear courses failing which the candidate will not be permitted to move on to the higher semester. This will not be applicable for the courses which do not have an end semester examination.

6.2 The candidates who need to reappear for the courses which have only continuous assessment shall enroll for the same in the subsequent semester, when offered next, and repeat the course. In this case, the candidate shall attend the classes, satisfy the attendance requirements (vide clause 8), earn continuous assessment marks. This will be considered as an attempt for the purpose of classification.

6.3 If a candidate is prevented from writing end semester examination of a course due to lack of attendance, the candidate has to attend the classes, when offered next, and fulfill the attendance requirements as per clause 8 and earn continuous assessment marks. If the course, in which the candidate has a lack of attendance, is an elective, the candidate may register for the same or any other elective course in the subsequent semesters and that will be considered as an attempt for the purpose of classification.

7. ASSESSMENT AND EXAMINATION PROCEDURE FOR AWARDING MARKS

7.1 The ME/MTech programmes consist of Theory Courses, Theory cum Practical courses, Practical courses, Innovative Project, Internship cum Project work and Project Work. Performance in each course of study shall be evaluated based on (i) Continuous Assessments (CA) throughout the semester and (ii) End Semester Examination (ESE) at the end of the semester except for the courses which are evaluated based on continuous assessment only. Each course shall be evaluated for a maximum of 100 marks as shown below:

Sl. No.	Category of Course	Continuous Assessment Marks	End Semester Examination
1.	Theory / Practical	50	50
2.	Theory cum Practical	The distribution of marks shall be decided based on the credit weightage assigned to theory and practical components respectively.	
3.	Innovative Project/ Project Work / Internship cum Project Work	50	50
4.	Value Added Course	The distribution of marks shall be decided based on the credit the credit weightage assigned	---
5.	All other Courses		

7.2 Examiners for setting end semester examination question papers for theory courses, theory cum practical courses and practical courses and evaluating end semester examination answer scripts, project works, innovative project and internships shall be appointed by the Controller of Examinations after obtaining approval from the Principal.

7.3 Theory Courses

For all theory courses out of 100 marks, the continuous assessment shall be 50 marks and the end semester examination shall be for 50 marks. However, the end semester examinations shall be conducted for 100 marks and the marks obtained shall be reduced to 50. The continuous assessment tests shall be conducted as per the schedule laid down in the academic schedule. Three tests shall be conducted for 50 marks each and reduced to 30 marks each. The total of the continuous assessment marks and the end semester examination marks shall be rounded off to the nearest integer.

7.3.1 The assessment pattern for awarding continuous assessment marks shall be as follows:

Sl. No.	Type	Max. Marks	Remarks
1.	Test – I	30	Average o f best two
	Test – II	30	
	Test - III	30	
2.	Tutorial	15	Should be of Open Book/Objective Type. Average of best 4 (or more, depending on the nature of the course, as may be approved by Principal)

3.	Assignment / Paper Presentation in Conference / Seminar / Comprehension / Activity based learning / Class notes	05	To be assessed by the Course Teacher based on any one type.
	Total	50	Rounded off to the one decimal place

However, the assessment pattern for awarding the continuous assessment marks may be changed based on the nature of the course and is to be approved by the Principal.

7.3.2 A reassessment test or tutorial covering the respective test or tutorial portions may be conducted for those candidates who were absent with valid reasons (Sports or any other reason approved by the Principal).

7.3.3 The end semester examination for theory courses shall be for duration of three hours.

7.4 Theory cum Practical Courses

For courses involving theory and practical components, the evaluation pattern as per the clause 7.1 shall be followed. Depending on the nature of the course, the end semester examination shall be conducted for theory and the practical components. The apportionment of continuous assessment and end semester examination marks shall be decided based on the credit weightage assigned to theory and practical components approved by Principal.

7.5 Practical Courses

For all practical courses out of 100 marks, the continuous assessment shall be for 50 marks and the end semester examination shall be for 50 marks. Every exercise / experiment shall be evaluated based on the candidate’s performance during the practical class and the candidate's records shall be maintained.

7.5.1 The assessment pattern for awarding continuous assessment marks for each course shall be decided by the course coordinator based on rubrics of that particular course, and shall be based on rubrics for each experiment.

7.6 Project Work

7.6.1 Project work shall becarried out individually. Candidates can opt for full time internship (vide clause 7.8) in lieu of project work in third semester. The project work is mandatory for all the candidates.

7.6.2 The Head of the Department shall constitute review committee for project work. There shall be three assessments by the review committee during the semester. The candidate shall make presentation on the progress made by him/her before the committee.

7.6.3 The continuous assessment and end semester examination marks for Project Work and the Viva-Voce Examination shall be distributed as below.

Continuous Assessment (Max. 50 Marks)						End Semester Examination (Max. 50 Marks)			
Review I (Max..10 Marks)		Review II (Max.. 20 Marks)		Review III (Max. 20 Marks)		Report Evaluation (Max. 20 Marks)	Viva - Voce (Max. 30 Marks)		
Rv. Com	Guide	Review Committee (excluding guide)	Guide	Review Committee (excluding guide)	Guide	Ext. Exr.	Guide	Exr. 1	Exr. 2
5	5	10	10	10	10	20	10	10	10

7.6.4 The Project Report prepared according to approved guidelines and duly signed by the Guide and Project Co-ordinator shall be submitted to Head of the Department. A candidate must submit the project report within the specified date as per the academic schedule of the semester. If the project report is not submitted within the specified date then the candidate is deemed to have failed in the Project Work and redo it in the subsequent semester. This applies to both Internship cum Project work and Project work.

7.6.5 If a candidate fails to secure 50% of the continuous assessment marks in the project work, he / she shall not be permitted to submit the report for that particular semester and shall have to redo it in the subsequent semester and satisfy attendance requirements.

7.6.6 Every candidate shall, based on his/her project work, publish a paper in a reputed journal or reputed conference in which full papers are published after usual review. A copy of the full paper accepted and proof for that shall be produced at the time of evaluation.

7.6.7 The project work shall be evaluated based on the project report submitted by the candidate in the respective semester and viva-voce examination by a committee consisting of two examiners and guide of the project work.

7.6.8 If a candidate fails to secure 50 % of the end semester examination marks in the project work, he / she shall be required to resubmit the project report within 30 days from the date of declaration of the results and a fresh viva-voce examination shall be conducted as per clause 7.6.7.

7.6.9 A copy of the approved project report after the successful completion of viva-voce examination shall be kept in the department library.

7.7 Innovative Project

The evaluation method shall be same as that of the Project Work as per clause 7.6 excluding clause 7.6.6.

7.8 Internship cum Project Work

Each candidate shall submit a brief report about the internship undergone and a certificate issued from the organization concerned at the time of Viva-voce examination to the review committee. The evaluation method shall be same as that of the Project Work as per clause 7.6 excluding 7.6.6.

7.9 Value Added Course

Two assessments shall be conducted during the value added course duration by the offering department concerned.

7.10 Online Course

The Board of Studies will provide methodology for the evaluation of the online courses. The Board can decide whether to evaluate the online courses through continuous assessment and end semester examination or through end semester examination only. In case of credits earned through online mode from NPTEL / SWAYAM / a University / Other Agencies approved by Chairman, Academic Council, the credits may be transferred and grades shall be assigned accordingly.

7.11 Self Study Course

The member of faculty approved by the Head of the Department shall be responsible for periodic monitoring and evaluation of the course. The course shall be evaluated through continuous assessment and end semester examination. The evaluation methodology shall be the same as that of a theory course.

7.12 Audit Course

A candidate may be permitted to register for specific course not listed in his/her programme curriculum and without undergoing the rigors of getting a 'good' grade, as an Audit course, subject to the following conditions.

The candidate can register only one Audit course in a semester starting from second semester subject to a maximum of two courses during the entire programme of study. Such courses shall be indicated as 'Audit' during the time of Registration itself. Only courses currently offered for credit to the candidates of other branches can be audited.

A course appearing in the curriculum of a candidate cannot be considered as an audit course. However, if a candidate has already met the Professional Elective and Open Elective credit requirements as stipulated in the curriculum, then, a Professional Elective or an Open Elective course listed in the curriculum and not taken by the candidate for credit can be considered as an audit course.

Candidates registering for an audit course shall meet all the assessment and examination requirements (vide clause 7.3) applicable for a credit candidate of that course. Only if the candidate obtains a performance grade, the course will be listed in the semester Grade Sheet and in the Consolidated Grade Sheet along with the grade SF (Satisfactory). Performance grade will not be shown for the audit course.

Since an audit course has no grade points assigned, it will not be counted for the purpose of GPA and CGPA calculations.

8. REQUIREMENTS FOR COMPLETION OF A SEMESTER

8.1 A candidate who has fulfilled the following conditions shall be deemed to have satisfied the requirements for completion of a semester and permitted to appear for the examinations of that semester.

8.1.1 Ideally, every candidate is expected to attend all classes and secure 100 % attendance. However, a candidate shall secure not less than 80 % (after rounding off to the nearest integer) of the overall attendance taking into account the total number of working days in a semester.

8.1.2 A candidate who could not satisfy the attendance requirements as per clause 8.1.1 due to medical reasons (hospitalization / accident / specific illness) but has secured not less than 70 % in the current semester may be permitted to appear for the current semester examinations with the approval of the Principal on payment of a condonation fee as may be fixed by the authorities from time to time. The medical certificate needs to be submitted along with the leave application. A candidate can avail this provision only twice during the entire duration of the degree programme.

8.1.3 In addition to clause 8.1.1 or 8.1.2, a candidate shall secure not less than 60 % attendance in each course.

8.1.4 A candidate shall be deemed to have completed the requirements of study of any semester only if he/she has satisfied the attendance requirements (vide clause 8.1.1 to 8.1.3) and has registered for examination by paying the prescribed fee.

8.1.5 Candidate's progress is satisfactory.

8.1.6 Candidate's conduct is satisfactory and he/she was not involved in any indisciplined activities in the current semester.

8.2. The candidates who do not complete the semester as per clauses from 8.1.1 to 8.1.6 except 8.1.3 shall not be permitted to appear for the examinations at the end of the semester and not be permitted to go to the next semester. They have to repeat the incomplete semester in next academic year.

8.3 The candidates who satisfy the clause 8.1.1 or 8.1.2 but do not complete the course as per clause 8.1.3 shall not be permitted to appear for the end semester examination of that course alone. They have to repeat the incomplete course in the subsequent semester when it is offered next.

9. REQUIREMENTS FOR APPEARING FOR END SEMESTER EXAMINATION

9.1 A candidate shall normally be permitted to appear for end semester examination of the current semester if he/she has satisfied the semester completion requirements as per clause 8, and has registered for examination in all courses of that semester. Registration is mandatory for current semester examinations as well as for arrear examinations failing which the candidate shall not be permitted to move on to the higher semester.

9.2 When a candidate is deputed for a National / International Sports event during End Semester examination period, supplementary examination shall be conducted for such a candidate on return after participating in the event within a reasonable period of time. Such appearance shall be considered as first appearance.

9.3 A candidate who has already appeared for a course in a semester and passed the examination is not entitled to reappear in the same course for improvement of letter grades / marks.

10. PROVISION FOR WITHDRAWAL FROM EXAMINATIONS

10.1 A candidate may, for valid reasons, be granted permission to withdraw from appearing for the examination in any regular course or all regular courses registered in a particular semester. Application for withdrawal is permitted only once during the entire duration of the degree programme.

10.2 The withdrawal application shall be valid only if the candidate is otherwise eligible to write the examination (vide clause 9) and has applied to the Principal for permission prior to the last examination of that semester after duly recommended by the Head of the Department.

10.3 The withdrawal shall not be considered as an appearance for deciding the eligibility of a candidate for First Class with Distinction/First Class.

10.4 If a candidate 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 examinations. A final semester candidate who has withdrawn shall be permitted to appear for supplementary examination to be conducted within reasonable time as per clause 14.

10.5 The final semester candidate who has withdrawn from appearing for project viva-voce for genuine reasons shall be permitted to appear for supplementary viva-voce examination within reasonable time with proper application to Controller of Examinations and on payment of prescribed fee.

11. PROVISION FOR BREAK OF STUDY

11.1 A candidate is normally permitted to avail the authorised break of study under valid reasons (such as accident or hospitalization due to prolonged ill health or any other valid reasons) and to rejoin the programme in a later semester. He/She shall apply in advance to the Principal, through the Head of the Department, stating the reasons therefore, in any case, not later than the last date for registering for that semester examination. A candidate is permitted to avail the authorised break of study only once during the entire period of study for a maximum period of one year. However, in extraordinary situation the candidate may apply for additional break of study not exceeding another one year by paying prescribed fee for the break of study.

11.2 The candidates permitted to rejoin the programme after break of study / prevention due to lack of attendance shall be governed by the rules and regulations in force at the time of rejoining.

11.3 The candidates rejoining in new Regulations shall apply to the Principal in the prescribed format through Head of the Department at the beginning of the readmitted semester itself for prescribing additional/equivalent courses, if any, from any semester of the regulations in-force, so as to bridge the curriculum in-force and the old curriculum.

11.4 The total period of completion of the programme reckoned from the commencement of the semester to which the candidate was admitted shall not exceed the maximum period specified in clause 5 irrespective of the period of break of study in order to qualify for the award of the degree.

11.5 If any candidate is prevented for want of required attendance, the period of prevention shall not be considered as authorized break of study.

11.6 If a candidate has not reported to the college for a period of two consecutive semesters without any intimation, the name of the candidate shall be deleted permanently from the college enrollment. Such candidates are not entitled to seek readmission under any circumstances.

12. PASSING REQUIREMENTS

12.1 A candidate who secures not less than 50 % of total marks (continuous assessment and end semester examination put together) prescribed for the course with a minimum of 50 % of the marks prescribed for the end semester examination in all category of courses vide clause 7.1 except for the courses which are evaluated based on continuous assessment only shall be declared to have successfully passed the course in the examination.

12.2 A candidate who secures not less than 50 % in continuous assessment marks prescribed for the courses which are evaluated based on continuous assessment only shall be declared to have successfully passed the course. If a candidate secures less than 50% in the continuous assessment marks, he / she shall have to re-enroll for the same in the subsequent semester and satisfy the attendance requirements.

12.3 For a candidate who does not satisfy the clause 12.1, the continuous assessment marks secured by the candidate in the first attempt shall be retained and considered valid for subsequent attempts. However, from the fourth attempt onwards the marks scored in the end semester examinations alone shall be considered, in which case the candidate shall secure minimum 50 % marks in the end semester examinations to satisfy the passing requirements, but the grade awarded shall be only the lowest passing grade irrespective of the marks secured.

13. REVALUATION OF ANSWER SCRIPTS

A candidate shall apply for a photocopy of his / her semester examination answer script within a reasonable time from the declaration of results, on payment of a prescribed fee by submitting the proper application to the Controller of Examinations. The answer script shall be pursued and justified jointly by a faculty member who has handled the course and the course coordinator and recommended for revaluation. Based on the recommendation, the candidate can register for revaluation through proper application to the Controller of Examinations. The Controller of Examinations will arrange for revaluation and the results will be intimated to the candidate concerned. Revaluation is permitted only for Theory courses and Theory cum Practical courses where end semester examination is involved.

14. SUPPLEMENTARY EXAMINATION

If a candidate fails to clear all courses in the final semester after the announcement of final end semester examination results, he/she shall be allowed to take up supplementary examinations to be conducted within a reasonable time for the courses of final semester alone, so that he/she gets a chance to complete the programme.

15. AWARD OF LETTER GRADES

Range of % of Total Marks	Letter Grade	Grade Point
91 to 100	O (Outstanding)	10
81 to 90	A+ (Excellent)	9
71 to 80	A (Very Good)	8
61 to 70	B+ (Good)	7
50 to 60	B (Average)	6
Less than 50	RA (Reappear)	0
Satisfactory	SF	0
Withdrawal	W	-
Absent	AB	-
Shortage of Attendance in a course	SA	-

The Grade Point Average (GPA) is calculated using the formula:

$$\text{GPA} = \frac{\sum[(\text{course credits}) \times (\text{grade points})] \text{ for all courses in the specific semester}}{\sum(\text{course credits}) \text{for all courses in the specific semester}}$$

The Cumulative Grade Point Average (CGPA) is calculated from first semester (third semester for lateral entry candidates) to final semester using the formula

$$\text{CGPA} = \frac{\sum[(\text{course credits}) \times (\text{grade points})] \text{ for all courses in all the semesters so far}}{\sum(\text{course credits}) \text{for all courses in all the semesters so far}}$$

The GPA and CGPA are computed only for the candidates with a pass in all the courses.

The GPA and CGPA indicate the academic performance of a candidate at the end of a semester and at the end of successive semesters respectively.

A grade sheet for each semester shall be issued containing Grade obtained in each course, GPA and CGPA.

A duplicate copy, if required can be obtained on payment of a prescribed fee and satisfying other procedure requirements.

Withholding of Grades: The grades of a candidate may be withheld if he/she has not cleared his/her dues or if there is a disciplinary case pending against him/her or for any other reason.

16. ELIGIBILITY FOR THE AWARD OF DEGREE

A candidate shall be declared to be eligible for the award of the ME / MTech Degree provided the candidate has

i. Successfully completed all the courses under the different categories, as specified in the regulations.

ii. Successfully gained the required number of total credits as specified in the curriculum corresponding to the candidate's programme within the stipulated time (vide clause 5).

iii. Successfully passed any additional courses prescribed by the respective Board of Studies whenever readmitted under regulations other than R-2020 (vide clause 11.3)

iv. No disciplinary action pending against him / her.

17. CLASSIFICATION OF THE DEGREE AWARDED

17.1 First Class with Distinction:

17.1.1 A candidate who qualifies for the award of the degree (vide clause 16) and 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 **First Appearance** within four consecutive semesters excluding the authorized break of study (vide clause 11) after the commencement of his / her study.
- Withdrawal from examination (vide clause 10) shall not be considered as an appearance.
- Should have secured a CGPA of not less than 8.50

(OR)

17.1.2 A candidate who joins from other institutions on transfer or a candidate who gets readmitted and has to move from one regulation to another regulation and who qualifies for the award of the degree (vide clause 16) and 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 **First Appearance** within four consecutive semesters excluding the authorized break of study (vide clause 11) after the commencement of his / her study.
- Submission of equivalent course list approved by the respective Board of studies.
- Withdrawal from examination (vide clause 10) shall not be considered as an appearance.
- Should have secured a CGPA of not less than 9.00

17.2 First Class:

A candidate who qualifies for the award of the degree (vide clause 16) and 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 six consecutive semesters excluding authorized break of study (vide clause 11) after the commencement of his / her study.
- Withdrawal from the examination (vide clause 10) shall not be considered as an appearance.
- Should have secured a CGPA of not less than 7.00

17.3 Second Class:

All other candidates (not covered in clauses 17.1 and 17.2) who qualify for the award of the degree (vide clause 16) shall be declared to have passed the examination in Second Class.

17.4 A candidate who is absent for end semester examination in a course / project work after having registered for the same shall be considered to have appeared for that examination for the purpose of classification.

18. MALPRACTICES IN TESTS AND EXAMINATIONS

If a candidate indulges in malpractice in any of the tests or end semester examinations, he/she shall be liable for punitive action as per the examination rules prescribed by the college from time to time.

19. AMENDMENTS

Notwithstanding anything contained in this manual, the Kongu Engineering College through the Academic council of the Kongu Engineering College, reserves the right to modify/amend without notice, the Regulations, Curricula, Syllabi, Scheme of Examinations, procedures, requirements, and rules pertaining to its ME / MTech programme.

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CURRICULUM BREAKDOWN STRUCTURE						
Summary of Credit Distribution						
Category	**Semester**				**Total number of credits**	**Curriculum Content (% of total number of credits of the program)**
	I	**II**	**III**	**IV**		
FC	**7**	**-**	**-**	**-**	**7**	**9.72**
PC	**13**	**14**	**-**	**-**	**27**	**37.50**
PE	**3**	**6**	**3**	**6**	**18**	**25**
EC		**2**	**9**	**9**	**20**	**27.78**
Semesterwise Total	**22**	**23**	**12**	**15**	**72**	**100.00**

Category	Abbreviation
Lecture hours per week	**L**
Tutorial hours per week	**T**
Practical, Project work, Internship, Professional Skill Training, Industrial Training hours per week	**P**
Credits	**C**

CATEGORISATION OF COURSES							
FOUNDATION COURSES (FC)							
S. No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**	**Sem**
1.	20AMT14	Applied Mathematics for Electrical Engineers	3	1	0	4	I
2.	20GET11	Introduction to Research	2	1	0	3	1
Total Credits to be earned						7	

PROFESSIONAL CORE (PC)								
S. No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**	**Sem**	**Domain/ Stream**
1.	20GET11	Introduction to Research	2	1	0	3	I	GE
2.	20PET11	Power Semiconductor Devices	3	1	0	4	I	PE
3.	20PET12	A.C. Converters	3	0	0	3	I	PE
4.	20PET13	D.C. Converters	3	0	0	3	I	PE
5.	20PEL11	Power Converters Laboratory	0	0	2	1	I	PE
6.	20PEL12	Renewable Energy Laboratory	0	0	2	1	I	PE

7.	20PET21	Special Electrical Machines	3	0	0	3	II	EM
8.	20PET22	Electrical Drives	3	1	0	4	II	PE
9.	20PET23	Modeling and Analysis of Electrical Machines	3	1	0	4	II	EM
10.	20PET24	Distributed Generation	3	0	0	3	II	EM
11.	20PEL21	Solid State Drives and Control Laboratory	0	0	2	1	II	PE
Total Credits to be earned						30		
PROFESSIONAL ELECTIVE (PE)								
S. No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**	**Sem**	**Domain/ Stream**
1.	20PEE01	Optimization Techniques	3	0	0	3	I	CA
2.	20PEE02	Programmable Logic Controllers	3	0	0	3	I	CA
3.	20PEE03	Virtual Instrumentation for Industrial Applications	3	0	0	3	I	CA
4.	20PEE04	SCADA and DCS	3	0	0	3	I	CA
5.	20PEE05	Power Electronics for Solar and Wind Energy Conversion Systems	3	0	0	3	II	EN
6.	20PEE06	Advanced Power Converters	3	0	0	3	II	PE
7.	20PEE07	Computer Aided Design of Electrical Machines	3	0	0	3	II	EM
8.	20PEE08	Power Quality Engineering	3	0	0	3	II	PE
9.	20PEE09	Control Design Technique for Power Electronics Systems	3	0	0	3	II	PE
10.	20PEE10	Resonant Converters	3	0	0	3	II	PE
11.	20PEE11	Microgrid and Smart Grid	3	0	0	3	II	EN
12.	20PEE12	Electric Vehicle Systems	3	0	0	3	II	EN
13.	20PEE13	PWM Techniques and its Applications	3	0	0	3	III	PE
14.	20PEE14	Computer Aided Simulation and Design of Power Electronic Systems	3	0	0	3	III	PE
15.	20PEE15	Energy Conservation, Management and Auditing	3	0	0	3	III	EN
16.	20PEE16	Vector Control Of AC machines	3	0	0	3	III	EM
17.	20PEE17	Electromagnetic Field Computation and Modeling	3	0	0	3	IV	EM
18.	20PEE18	Intelligent Controllers	3	0	0	3	IV	PE
19.	20PEE19	System Theory	3	0	0	3	IV	CA
20.	20PEE20	Biomedical Instrumentation	3	0	0	3	IV	OT
21.	20PEE21	Microcontroller Based System Design	3	0	0	3	IV	OT
22.	20PEE22	Electrical Safety Engineering	3	0	0	3	IV	OT
23.	20PEE23	Project Management	3	0	0	3	IV	OT

24.	20PEE24	HVDC AND FACTS	3	0	0	3	IV	OT
25.	20PEE25	Embedded System and Applications	3	0	0	3	IV	OT
26.	20PEE26	Energy Storage Systems	3	0	0	3	IV	EN
27.	20GET13	innovation and Business Model Development	3	0	0	3	IV	OT
Total Credits to be earned						18		

***** Domain/Stream Abbreviations: CA- Control and Automation Engineering, EN-Energy , PE- Power Electronics , OT– Other Technologies, EM- Electrical Machines, GE – General Engineering

EMPLOYABILITY ENHANCEMENT COURSES (EC)							
S. No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**	**Sem**
1.	20PEP21	Innovative Project	0	0	4	2	II
2.	20PEP31	Internship cum Project Work	0	0	18	9	III
3.	20PEP41	Project Work 2	0	0	18	9	IV
Total Credits to be earned						20	

KEC R2020: SCHEDULING OF COURSES – M.E (Power Electronics and Drives)

Semester	Course1	Course2	Course3	Course4	Course5	Course6	Course7	L	Credits
I	20AMT14 - Advanced Mathematics for Electrical Engineers (FC-3-1-0-4)	20GET11- Introduction to Research (PC-2-1-0-3)	20PET11 Power Semiconductor Devices (PC-3-1-0-4)	20PET12- A.C. Converters (PC-3-0-3-3)	20PET13- D.C. Converters (PC-3-0-3-3)	Elective I (PE-3-0-0-3)	20PEL11- Power Converters Laboratory (PC-0-0-2-1)	20PEL12- Renewable Energy Laboratory (PC-0-0-2-1)	22
II	20PET21 - Special Electrical Machines (PC-3-0-3-3)	20PET22 - Electrical Drives (PC-3-1-0-4)	20PET23- Modeling and Analysis of Electrical Machines (PC-3-1-0-4)	20PET24- Distributed Generation (PC-3-0-0-3)	Elective-II (Professional) (PE-3-0-0-3)	Elective-III (Professional) (PE-3-0-0-3)	20PEL21- Solid State Drives and Control Laboratory (PC-0-0-2-1)	20PEP21- Innovative Project (EC-0-0-4-2)	23
III	Elective-IV (PE-3-0-0-3)	20PEP31- Internship cum Project Work (EC-0-0-18-9)							12
IV	20PEP41- Project Work 2 (EC-0-0-18-9)								15

Total :72

MAPPING OF COURSES WITH PROGRAM OUTCOMES

Sem.	Course Code	Course Title	PO1	PO2	PO3
I	20AMT14	Applied Mathematics for Electrical Engineers	✓	✓	✓
I	20GET11	Introduction to Research	✓	✓	✓
I	20PET11	Power Semiconductor Devices	✓	✓	✓
I	20PET12	A.C. Converters	✓	✓	✓
I	20PET13	D.C. Converters	✓	✓	✓
I	20PEL11	Power Converters Laboratory	✓	✓	✓
I	20PEL12	Renewable Energy Laboratory	✓	✓	✓
II	20PET21	Special Electrical Machines	✓	✓	✓
II	20PET22	Electrical Drives	✓	✓	✓
II	20PET23	Modeling and Analysis of Electrical Machines	✓	✓	✓
II	20PET24	Distributed Generation	✓	✓	✓
II	20PEL21	Solid State Drives and Control Laboratory	✓	✓	✓
II	20PEP21	Innovative Project	✓	✓	✓
III	20PEP31	Internship cum Project Work	✓	✓	✓
IV	20PEP41	Project Work 2	✓	✓	✓
		Professional Elective Courses			
I	20PEE01	Optimization Techniques	✓	✓	✓
I	20PEE02	Programmable Logic Controllers	✓	✓	✓
I	20PEE03	Virtual Instrumentation for Industrial Applications	✓	✓	✓
I	20PEE04	SCADA and DCS	✓	✓	✓
II	20PEE05	Power Electronics for Solar and Wind Energy Conversion Systems	✓	✓	✓
II	20PEE06	Advanced Power Converters	✓	✓	✓
II	20PEE07	Computer Aided Design of Electrical Machines	✓	✓	✓
II	20PEE08	Power Quality Engineering	✓	✓	✓

II	20PEE09	Control Design Technique for Power Electronics Systems	✓	✓	✓
II	20PEE10	Resonant Converters	✓	✓	✓
II	20PEE11	Microgrid and Smart Grid	✓	✓	✓
II	20PEE12	Electric Vehicle Systems	✓	✓	✓
III	20PEE13	PWM Techniques and its Applications	✓	✓	✓
III	20PEE14	Computer Aided Simulation and Design of Power Electronic Systems	✓	✓	✓
III	20PEE15	Energy Conservation, Management and Auditing	✓	✓	✓
III	20PEE16	Vector Control Of AC machines	✓	✓	✓
IV	20PEE17	Electromagnetic Field Computation and Modeling	✓	✓	✓
IV	20PEE18	Intelligent Controllers	✓	✓	✓
IV	20PEE19	System Theory	✓	✓	✓
IV	20PEE20	Biomedical Instrumentation	✓	✓	✓
IV	20PEE21	Microcontroller Based System Design	✓	✓	✓
IV	20PEE22	Electrical Safety Engineering	✓	✓	✓
IV	20PEE23	Project Management	✓	✓	✓
IV	20PEE24	HVDC AND FACTS	✓	✓	✓
IV	20PEE25	Embedded System and Applications	✓	✓	✓
IV	20PEE26	Energy Storage Systems	✓	✓	✓
IV	20GET13	Innovation and Business Model Development	✓	✓	✓

CURRICULUM FROM 1ST SEMESTER TO 4TH SEMESTER FOR ME (POWER ELECTRONICS AND DRIVES)

SEMESTER – I									
Sl.No.	Course Title	Hours / Week			Credit	Maximum Marks			Category
		L	T	P		CA	ESE	Total	
Theory/Theory with Practical									
20AMT14	Applied Mathematics for Electrical Engineers	3	1	0	4	50	50	100	FC
20GET11	Introduction to Research	2	1	0	3	50	50	100	FC
20PET11	Power Semiconductor Devices	3	1	0	4	50	50	100	PC
20PET12	A.C. Converters	3	0	0	3	50	50	100	PC
20PET13	D.C. Converters	3	0	0	3	50	50	100	PC
	Professional Elective-I	3	0	0	3	50	50	100	PE
Practical / Employability Enhancement									
20PEL11	Power Converters Laboratory	0	0	2	1	50	50	100	PC
20PEL12	Renewable Energy Laboratory	0	0	2	1	50	50	100	PC
Total Credits to be earned					**22**				

SEMESTER – II									
Sl.No.	Course Title	Hours / Week			Credit	Maximum Marks			Category
		L	T	P		CA	ESE	Total	
Theory/Theory with Practical									
20PET21	Special Electrical Machines	3	0	0	3	50	50	100	PC
20PET22	Electrical Drives	3	1	0	4	50	50	100	PC
20PET23	Modeling and Analysis of Electrical Machines	3	1	0	4	50	50	100	PC
20PET24	Distributed Generation	3	0	0	3	50	50	100	PC
	Professional Elective II	3	0	0	3	50	50	100	PE
	Professional Elective III	3	0	0	3	50	50	100	PE
Practical / Employability Enhancement									
20PEL21	Solid State Drives and Control Laboratory	0	0	2	1	50	50	100	PC
20PEP21	Innovative Project	0	0	4	2	50	50	100	EC
Total Credits to be earned					**23**				

SEMESTER – III									
Sl.No.	Course Title	Hours / Week			Credit	Maximum Marks			Category
		L	T	P		CA	ESE	Total	
Theory/Theory with Practical									
	Professional Elective IV	3	0	0	3	50	50	100	PE
Practical / Employability Enhancement									
20PEP31	Internship cum Project Work	0	0	18	9	50	50	100	EC
Total Credits to be earned					**12**				

Intern students can study the Elective 4 (Sl. No. 3.1) through NPTEL/MOOC portals also.

SEMESTER – IV									
Sl.No.	Course Title	Hours / Week			Credit	Maximum Marks			Category
		L	T	P		CA	ESE	Total	
Theory/Theory with Practical									
	Professional Elective-V	3	0	0	3	50	50	100	PE
	Professional Elective-VI	3	0	0	3	50	50	100	PE
Practical / Employability Enhancement									
20PEP41	Project Work 2	0	0	18	9	50	50	100	EC
Total Credits to be earned					**15**				

PROFESSIONAL ELECTIVE (PE)

S. No.	Course Code	Course Name	L	T	P	C	Sem
		Elective 1					
1.	20PEE01	Optimization Techniques	3	0	0	3	I
2.	20PEE02	Programmable Logic Controllers	3	0	0	3	I
3.	20PEE03	Virtual Instrumentation for Industrial Applications	3	0	0	3	I
4.	20PEE04	SCADA and DCS	3	0	0	3	I
5.	20PEE05	Power Electronics for Solar and Wind Energy Conversion Systems	3	0	0	3	II
6.	20PEE06	Advanced Power Converters	3	0	0	3	II
7.	20PEE07	Computer Aided Design of Electrical Machines	3	0	0	3	II
8.	20PEE08	Power Quality Engineering	3	0	0	3	II
9.	20PEE09	Control Design Technique for Power Electronics Systems	3	0	0	3	II
10.	20PEE10	Resonant Converters	3	0	0	3	II
11.	20PEE11	Microgrid and Smart Grid	3	0	0	3	II
12.	20PEE12	Electric Vehicle Systems	3	0	0	3	II
13.	20PEE13	PWM Techniques and its Applications	3	0	0	3	III
14.	20PEE14	Computer Aided Simulation and Design of Power Electronic Systems	3	0	0	3	III
15.	20PEE15	Energy Conservation, Management and Auditing	3	0	0	3	III
16.	20PEE16	Vector Control Of AC machines	3	0	0	3	III
17.	20PEE17	Electromagnetic Field Computation and Modeling	3	0	0	3	IV
18.	20PEE18	Intelligent Controllers	3	0	0	3	IV
19.	20PEE19	System Theory	3	0	0	3	IV
20.	20PEE20	Biomedical Instrumentation	3	0	0	3	IV
21.	20PEE21	Microcontroller Based System Design	3	0	0	3	IV
22.	20PEE22	Electrical Safety Engineering	3	0	0	3	IV
23.	20PEE23	Project Management	3	0	0	3	IV
24.	20PEE24	HVDC AND FACTS	3	0	0	3	IV
25.	20PEE25	Embedded System and Applications	3	0	0	3	IV

26.	20PEE26	Energy Storage Systems	3	0	0	3	IV
27.	20GET13	Innovation and Business Model Development	3	0	0	3	IV

20AMT14 - APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERS

(Common to Power Electronics and Drives & Control and Instrumentation**)**

Programme & Branch	**M.E. & Control and Instrumentation Engineering**	**Sem.**	**Category**	**L**	**T**	**P**	**Credit**
Prerequisites	**Nil**	**I**	**FC**	**3**	**1**	**0**	**4**

Preamble	This course will help the students to identify, formulate and solve problems in electrical and instrumentation engineering using mathematical tools from a variety of mathematical areas such as matrix and graph theory, queuing theory and linear programming.	
Unit - I	**Advanced Matrix Theory**	**9+3**
Positive definite matrices – Cholesky decomposition – Generalized Eigenvectors – Canonical basis – QR factorization – Generalized inverses – Singular value decomposition – Least squares solution.		
Unit - II	**Graph Theory**	**9+3**
Introduction of graphs – Isomorphism – Subgraphs – Walks, paths and circuits – Connected graphs – Eulerian Graphs – Hamiltonian Paths and circuits – Digraph – Adjacency matrix and incidence matrix of graphs – Applications: Shortest path algorithms – Dijkstra's algorithm – Warshall's algorithm – Trees – Properties of trees – Spanning trees – Applications of trees: Minimal spanning trees – Prim's Algorithm – Kruskal's algorithm.		
Unit - III	**Stochastic Process**	**9+3**
Definition – Classification of Stochastic Processes – Markov Chain -Transition Probability Matrices – Chapman Kolmogorov Equations - Classification of States – Continuous Time Markov Chains – Poisson Process - Birth and Death Processes.		
Unit - IV	**Queuing Models**	**9+3**
Markovian queues – Single and Multi-server Models – Little's formula – Machine Interference Model - Non- Markovian Queues – Pollaczek Khintchine Formula.		
Unit - V	**Linear Programming**	**9+3**
Mathematical Formulation of LPP – Basic definitions – Solutions of LPP: Graphical method – Simplex method – Transportation Model – Mathematical Formulation – Initial Basic Feasible Solution: North west corner rule – Vogel's approximation method – Optimum solution by MODI method – Assignment Model – Mathematical Formulation – Hungarian algorithm.		

Lecture:45, Tutorial:15, Total:60

REFERENCES:

1	Bronson, R., "Matrix Operations", Schaum's Outline Series, McGraw Hill, 2011.
2	Narsing Deo, "Graph Theory with Applications to Engineering and Computer science", Prentice Hall of India limited, 2005.
3	Roy D.Yates and David J Goodman, "Probability and Stochastic Processes – A friendly Introduction for Electrical and Computer Engineers", John Wiley & Sons, 2005.
4	Kanti Swarup, Gupta, P.K and Man Mohan "Operations Research", S.Chand & Co., 1997.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	apply various methods in matrix theory to solve system of linear equations.	Applying (K3)
CO2	apply graph theoretic algorithms in design of systems.	Applying (K3)

CO3	use discrete time Markov chains in real time systems.	Applying (K3)
CO4	identify the suitable queuing model to handle electronics and control engineering problems.	Applying (K3)
CO5	formulate mathematical models for linear programming problems and solve the transportation and assignment problems.	Applying (K3)

Mapping of COs with POs and PSOs				
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**
CO1	2			
CO2	2			
CO3	2			
CO4	3			
CO5	3			
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy				

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	20	70	-	-	-	100
CAT2	10	20	70	-	-	-	100
CAT3	10	20	70	-	-	-	100
ESE	10	20	70	-	-	-	100

*** +3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20GET11 INTRODUCTION TO RESEARCH

(Common to Engineering and Technology Branches)

Programme & Branch	M.E.- Embedded Systems	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	1	FC	2	1	0	3

Preamble	Preamble: This course will familiarize the fundamental concepts/techniques adopted in research, problem formulation and patenting. Also will disseminate the process involved in collection, consolidation of published literature and rewriting them in a presentable form using latest tools.	
Unit - I	**Concept of Research**	**6**
Meaning and Significance of Research: Skills, Habits and Attitudes for Research - Time Management - Status of Research in India. Why, How and What a Research is? - Types and Process of Research - Outcome of Research - Sources of Research Problem - Characteristics of a Good Research Problem - Errors in Selecting a Research Problem - Importance of Keywords - Literature Collection – Analysis - Citation Study - Gap Analysis - Problem Formulation Techniques.		
Unit - II	**Research Methods and Journals**	**6**
Interdisciplinary Research - Need for Experimental Investigations - Data Collection Methods - Appropriate Choice of Algorithms / Methodologies / Methods - Measurement and Result Analysis - Investigation of Solutions for Research Problem - Interpretation - Research Limitations. Journals in Science/Engineering - Indexing and Impact factor of Journals - Citations - h Index - i10 Index - Journal Policies - How to Read a Published Paper - Ethical issues Related to Publishing - Plagiarism and Self-Plagiarism.		
Unit - III	**Paper Writing and Research Tools**	**6**
Types of Research Papers - Original Article/Review Paper/Short Communication/Case Study - When and Where to Publish? - Journal Selection Methods. Layout of a Research Paper - Guidelines for Submitting the Research Paper - Review Process - Addressing Reviewer Comments. Use of tools / Techniques for Research - Hands on Training related to Reference Management Software - EndNote, Software for Paper Formatting like LaTeX/MS Office. Introduction to Origin, SPSS, ANOVA etc., Software for detection of Plagiarism.		
Unit - IV	**Effective Technical Thesis Writing/Presentation**	**6**
How to Write a Report - Language and Style - Format of Project Report - Use of Quotations - Method of Transcription Special Elements: Title Page - Abstract - Table of Contents - Headings and Sub-Headings - Footnotes - Tables and Figures - Appendix - Bibliography etc. - Different Reference Formats. Presentation using PPTs.		
Unit - V	**Nature of Intellectual Property**	**6**
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.		

Lecture: 30, Tutorial:15, Total:45

REFERENCES:

1	DePoy, Elizabeth, and Laura N. Gitlin, “Introduction to Research-E-Book: Understanding and Applying Multiple Strategies”, Elsevier Health Sciences, 2015.
2	Walliman, Nicholas, “Research Methods: The basics”,Routledge, 2017.
3.	Bettig Ronald V., “Copyrighting culture: The political economy of intellectual property”,Routledge, 2018.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	list the various stages in research and categorize the quality of journals.	Analyzing (K4)
CO2	formulate a research problem from published literature/journal papers	Evaluating (K5)
CO3	write, present a journal paper/ project report in proper format	Creating (K6)
CO4	select suitable journal and submit a research paper.	Applying (K3)
CO5	compile a research report and the presentation	Applying (K3)

Mapping of COs with POs and PSOs					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	2	1		
CO2	3	2	3		
CO3	3	3	1		
CO4	3	2	1		
CO5	3	2	1		
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy					

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1		30	40	30			100
CAT2		30	40	30			100
CAT3			30	40	30		100
ESE		30	40	30			100

*** ±3% may be varied**

20PET11 – POWER SEMICONDUCTOR DEVICES

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	1	PC	3	1	0	4

Preamble	The objective of this course is to the static and dynamic characteristics of current/voltage controlled power semiconductor devices, protection circuits and firing circuits.	
Unit - I	**Introduction**	**9+3**
Power switching devices overview – Attributes of an ideal switch, application requirements, circuit symbols; Power handling capability – (SOA); Device selection strategy – On-state and switching losses – EMI due to switching - Power diodes - Types, forward and characteristics, switching characteristics – rating.		
Unit - II	**Current Controlled Devices**	**9+3**
BJT's – Construction, static characteristics, switching characteristics; Power darlington- Thyristors – operating mode, Two transistor analogy – concept of latching; switching characteristics-series and parallel operation; comparison of BJT and Thyristor – steady state and dynamic models of BJT &Thyristor.		
Unit - III	**Voltage Controlled Devices**	**9+3**
Power MOSFETs and IGBTs – Principle of voltage controlled devices, construction, types, static and switching characteristics, steady state and dynamic models of MOSFET and IGBTs –Basics of GTO, MCT, and IGCT.		
Unit - IV	**Device Protection and Thermal Protection**	**9+3**
Necessity of isolation - Over voltage, over current and gate protections; Design of snubbers. Heat transfer – conduction, convection and radiation; Cooling – liquid cooling, vapour – phase cooling; Guidance for hear sink selection – Electrical analogy of thermal components, heat sink types and design – Mounting types		
Unit - V	**Firing Circuits**	**9+3**
Main features of firing circuits - Resistance and Resistance capacitance firing circuits, synchronized UJT firing circuit, ramp and pedestal triggering, pulse transformer firing circuit, triac firing circuit using a diac, Gating circuits for single phase converters and cosine firing scheme - Thyristor Protection.		

Lecture:45, Tutorial:15, Total:60

REFERENCES:

1.	Bimbhra P.S., "Power Electronics", 6th Edition, Khanna Publishers, Delhi, 2015.
2.	Singh M.D. and Khanchandani K B, "Power Electronics", 2nd Edition, Tata McGraw-Hill, New Delhi, 2016.
3.	Muhammad H.Rashid, "Power Electronics: Circuits, Devices and Applications", 4th Edition, Pearson Education, New Delhi, 2014.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	select the switching device suitable for given power electronic converter	Understanding (K2)
CO2	understand the principle of voltage controlled devices	Understanding (K2)
CO3	understand the principle of current controlled devices	Understanding (K2)
CO4	understand the control protection and firing circuits required for different switching devices	Understanding (K2)
CO5	Identify a suitable firing circuit for converters	Applying (K3)

Mapping of COs with POs and PSOs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	3		2
CO2	3		2
CO3	3		2
CO4	3	2	2
CO5	3	2	2
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	70					100
CAT2	30	50	20				100
CAT3	30	50	20				100
ESE	30	50	20				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20PET12 – AC CONVERTERS

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	1	PC	3	0	0	3

Preamble	The objective of this course is to bring the nuances behind the principle and operation of AC converters along with its applications in real time environment.	
Unit - I	**Single Phase Inverters**	**9**
Principle and Operation of Single Phase Inverters – Performance Parameters – Voltage Control – Advanced Modulation Techniques – Harmonic Reductions.		
Unit - II	**Inverter Configurations**	**9**
Three Phase Inverters: 180^0 and 120^0 Degree Conduction – Voltage Control of Three Phase Inverters – Current Source Inverter – Variable DC Link Inverter – Boost Inverter.		
Unit - III	**Multilevel Inverters**	**9**
Multilevel Concept – Types: Diode Clamped Multilevel Inverter, Flying Capacitor Multilevel Inverter, Cascaded Multilevel Inverter – Applications – Comparisons.		
Unit - IV	**Resonant Pulse Inverters**	**9**
Series Resonant Inverters – Parallel Resonant Inverters – Voltage Control of Resonant Inverters – Class E Resonant Inverter – Resonant DC Link Inverter.		
Unit - V	**AC-AC Converters**	**9**
Principle of ON OFF and Phase Control – Single Phase and Three Phase Configurations of Bidirectional Voltage Controllers. Cycloconverters: Single Phase and Three Phase Configurations – Matrix Converter.		

Lecture: 45, Total: 45

REFERENCES:

1	Rashid M.H., “Power Electronics: Circuits, Devices and Applications”, 3rd Edition, Pearson, New Delhi, 2014.
2	Bimbra P.S., “Power Electronics”, 5th Edition, Khanna Publishers, India,2012.
3	Sen P.C., “Modern Power Electronics”, 2nd Edition, S.Chand, India, 2008.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	explain the basic concepts of pulse width modulated inverters	Understanding (K2)
CO2	interpret various inverter configurations and its control methods	Understanding (K2)
CO3	examine the operation of multilevel inverters with its truth table	Applying (K3)
CO4	explain the concepts of resonant inverters	Understanding (K2)
CO5	illustrate the conversion concepts pertaining to AC/AC.	Understanding (K2)

Mapping of COs with POs and PSOs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3
CO4	3	2	3
CO5	3	2	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	70					100
CAT2	30	50	20				100
CAT3	30	70					100
ESE	30	50	20				100

*** ±3% may be varied**

20PET13 – D.C. CONVERTERS

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	1	PC	3	0	0	3

Preamble	The objective of this course is to study and analyze the characteristics of semiconductor devices and firing circuits. This course also brings an insight to principles of D.C converters.

Unit - I	**Single phase AC-DC Converters**	**9**
Principle of phase controlled converter operation: Single phase half controlled and fully controlled converters with R-L, R-L-E loads and freewheeling diodes – continuous and discontinuous modes of operation - inverter operation and analysis of single phase semi converter/half controlled converter: Asymmetric and Symmetric configurations-performance parameters: harmonics, ripple, distortion, power factor – effect of source impedance and overlap-reactive power and power balance in converter circuits.		
Unit - II	**Three Phase AC-DC Converters**	**9**
Operation of half wave converter-Full wave fully controlled converters: Analysis and operation with different type of loads-Rectification and inversion mode-semi controlled converter-Dual converter: Principal and operation-single phase and three phase configurations-12 pulse converter-Effect of source and load inductances-Applications of AC-DC converters.		
Unit - III	**DC-DC Converters**	**9**
Basic principle of DC chopper-classification of DC choppers-control strategies-Design and analysis of non-isolated converters: Buck, Boost, Buck-Boost, CUK, SEPIC, Zeta converters with continuous and discontinuous operation.		
Unit - IV	**Isolated Switch Mode Converters**	**9**
Design and analysis of isolated switch mode converters- fly back, forward, push-pull, and half bridge, full bridge Converters with continuous and discontinuous operation-Applications of DC-DC converters.		
Unit - V	**Bidirectional Dual Active Bridge DC–DC Converters**	**9**
Application of Bidirectional DC–DC Converter-Classification of Bidirectional DC–DC Converter -Working Principle of Hybrid-Bridge-Based Dual active bridge (DAB) converter- Performance- Voltage match control- Principle of Dual-Transformer based DAB converter- Three-Level bidirectional DC–DC converter		

Lecture: 45, Total: 45

REFERENCES:

1.	Bimbra P.S., “Power Electronics”, 6th Edition, Khanna Publishers, Delhi, 2015.
2.	Deshang Sha.Guo Xu ,”High-Frequency Isolated Bidirectional Dual Active Bridge DC–DC Converters with Wide Voltage Gain”, 1st Edition ,Springer. Singapore 2019.
3.	Muhammad H.Rashid, “Power Electronics: Circuits Devices and Applications”, 4th Edition, Pearson Education, New Delhi, 2014.

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1	describe the operation of single phase AC-DC converters and its performance parameters	Understanding (K2)
CO2	explain the working of three phase AC-DC converters and applications of AC-DC converters	Understanding (K2)
CO3	analyze and design of non-isolated DC to DC Converters	Analyzing (K4)
CO4	analyze the types of isolated DC to DC switched mode converters	Analyzing (K4)
CO5	understand the working and design of bi-directional DC-DC converters	Understanding (K2)

Mapping of COs with POs and PSOs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	3		2
CO2	3		2
CO3	3		3
CO4	3	2	3
CO5	3	2	2
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	70					100
CAT2	20	45	20	15			100
CAT3	30	40	20	10			100
ESE	25	40	20	15			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20PEL11 – POWER CONVERTERS LABORATORY

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	1	PC	0	0	2	1
Preamble	To explore the knowledge in various AC and DC converters and their design for the given condition.						

List of Exercises / Experiments:

1.	Design of snubber circuits, gate signal generation and driver circuits.
2.	Modeling and simulation of single phase controlled rectifier.
3.	Design and simulation of three-phase fully-controlled rectifiers
4.	Design and Simulation of non-isolated switch mode converters
5.	Design and Simulation of isolated switch mode converters
6.	Implementation of Voltage Source Inverter
7.	Implementation of single phase cyclo converters
8.	Simulation of Three Phase Full Bridge Inverter using PSIM
9.	Simulation of Three Phase AC Voltage Controller using PSPICE

Practical : 30,Total: 30

REFERENCES/MANUAL/SOFTWARE:

1.	MATLAB software
2.	Laboratory Manual

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	design basic snubber circuits and driver circuits	Applying (K3), Manipulation (S2)
CO2	design circuit for the given DC and AC converters	Applying (K3), Manipulation (S2)
CO3	understand the AC and DC drives	Understanding (K2), Manipulation (S2)

Mapping of COs with POs and PSOs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	3	2	3
CO2	3	2	3
CO3	3	3	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

20PEL12 – RENEWABLE ENERGY LABORATORY

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	1	PC	0	0	2	1
Preamble	To explore the knowledge in various renewable energy sources and its performance characteristics						

List of Exercises / Experiments :

1.	Study of PEFM fuel cell and evaluation of its VI characteristics using PEFM test station
2.	Study of solar photovoltaic tester and perform PV tests on the roof top PV panels
3.	Design and Simulation of PV supplied H-bridge inverter and extraction using dSPACE-1202 Microbox along with a MOSFET PWM driver circuit.
4.	Design and implementation of PV supplied Three phase inverter using RTI-FPGA module
5.	Study of Battery Simulator in CC,CV and CP mode and perform a battery charging analysis for a Lithium ion battery
6.	Investigate the presence of power quality indices in AC voltage and frequency control system using Chroma Programmable AC power source.
7.	
8.	
9.	
10.	
11.	
12.	

Practical : 30,Total: 30

REFERENCES/MANUAL/SOFTWARE:

1.	MATLAB software
2.	Manual

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	understand and analyze the VI characteristics of renewable sources	Applying (K3), Manipulation (S2)
CO2	design circuit for power converters and pwm generation using real time interface	Applying (K3), Manipulation (S2)
CO3	analysze of power quality indices in AC power source	Understanding (K3), Manipulation (S2)

Mapping of COs with POs and PSOs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	3	2	3
CO2	3	2	3

CO3	3	3	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

20PET21 – SPECIAL ELECTRICAL MACHINES

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	2	PC	3	0	0	3

Preamble	The objective of the course is to impart knowledge about the operations of the Special Electrical Machines and various controls methods of Special Machines.	
Unit - I	**Permanent Magnet Brushless D.C. Motors**	**9**
Permanent Magnet Brushless D.C. Motors: Construction - Principle of operation – Classification – Comparison between conventional DC and PMBLDC – Electronic commutation – Voltage equation – EMF and torque equations – Speed Torque relations – Sensors used for Rotor position – controllers for PMBLDC motor – Motor characteristics and Computer control.		
Unit - II	**Stepper Motors**	**9**
Stepper Motors : Classification – Construction – Principle of operation – Permanent Magnet motor – Variable reluctance motor – Hybrid motor – Single and multi-stack configurations – Modes of Excitation –Theory of torque predictions – Characteristics – Drive system and control circuitry – Applications – Simple problems.		
Unit - III	**Switched Reluctance Motors**	**9**
Switched Reluctance Motors : Constructional features – Principle of operation –Inductance profile – Voltage and Torque equation of SRM–Types of Power controllers and converter topologies – Current control schemes – Torque Speed Characteristics – Phase current analysis for low, Medium and High speed operation – Microprocessor based control –Simple Application problem.		
Unit - IV	**Permanent Magnet Synchronous Motors**	**9**
Permanent Magnet Synchronous Motors – Classifications – Construction - Principle of operation –EMF and torque equations – Phasor diagram – Locus diagram –Torque speed characteristics – Power controllers – Volt-ampere requirements –- Microprocessor based control.		
Unit - V	**Other Special Machines**	**9**
Other Special Machines: Vernier Motor – Principle of operation – Hysteresis Motor – Principle of operation – Characteristics – Linear Motor – AC Series Motor.		

Lecture: 45, Total: 45

REFERENCES:

1. Miller T.J.E., “Brushless Permanent Magnet and Reluctance Motor Drives”, Clarendon Press, Oxford,London (2 March 1989).
2. Aearnley P. P., “Stepping Motors” A Guide to Motor Theory and Practice”, Peter Perengrinus, London, 1982.
3. Kenjo T. and Nagamori S., “Permanent Magnet and Brushless DC Motors”, Clarendon Press, London, 1988.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	explain the construction and working principle of Permanent Magnet Brushless D.C. Motors and its Control.	Understanding (K2)
CO2	explain the construction and working principle of Stepper Motor and its control methods.	Understanding (K2)
CO3	explain the construction of Switched reluctance Motor and identify the control methods.	Applying (K3)
CO4	explain the construction and principle of operation of Permanent Magnet Synchronous Motors	Understanding (K2)
CO5	Outline the operation of other special machines.	Understanding (K2)

Mapping of COs with POs and PSOs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	2	1	
CO2	2	1	
CO3	3	2	1
CO4	2	1	
CO5	2	1	
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	70					100
CAT2	30	60	10				100
CAT3	40	60					100
ESE	30	50	20				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20PET22 – ELECTRICAL DRIVES

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	20PET12,20PET13	2	PC	3	1	0	4

Preamble	This course is designed to impart knowledge about the operation of speed control of DC motor and Induction Motor	
Unit - I	**DC Motors Fundamentals and Mechanical Systems**	**9+3**
DC motor- Types, induced emf, speed-torque relations; Speed control – Armature and field speed control; Ward Leonard control – Constant torque and constant horse power operation -Introduction to high speed drives and modern drives. Characteristics of mechanical system – dynamic equations, components of torque, types of load; Requirements of drives characteristics - stability of drives–multi-quadrant operation; Drive elements, types of motor duty and selection of motor rating.		
Unit - II	**Converter and Chopper Control**	**9+3**
Principle of phase control – Fundamental relations; Analysis of series and separately excited DC motor with single-phase and three-phase converters – performance parameters, performance characteristics. Introduction to time ratio control and frequency modulation; chopper controlled DC motor – performance analysis, multi-quadrant control – Chopper based implementation of braking schemes; Related problems.		
Unit - III	**Closed Loop Control**	**9+3**
Modeling of drive elements – Equivalent circuit, transfer function of self, separately excited DC motors; Linear Transfer function model of power converters; Sensing and feeds back elements - Closed loop speed control – current and speed loops, P, PI and PID controllers – response comparison. Simulation of converter and chopper fed DC drive.		
Unit - IV	**VSI and CSI Fed Stator Controlled Induction Motor Control**	**9+3**
AC voltage controller – six step inverter voltage control-closed loop variable frequency PWM inverter fed induction motor (IM) with braking-CSI fed IM variable frequency motor drives – pulse width modulation techniques – simulation of closed loop operation of stator controlled induction motor drives.		
Unit - V	**Rotor Controlled Induction Motor Drives**	**9+3**
Static rotor resistance control - injection of voltage in the rotor circuit – static scherbius drives – static and modified Kramer drives – sub-synchronous and super- synchronous speed operation of induction machines – simulation of closed loop operation of rotor controlled induction motor drives.		

Lecture:45, Tutorial:15, Total:60

REFERENCES:

1	Gopal K. Dubey, “Fundamentals of Electric Drives”, 2nd Edition, Narosa Publishing House, New Delhi , 2010.
2	Bimal K Bose, “Modern Power Electronics and AC Drives”, 1st Edition, Pearson Education India, New Delhi , 2015.
3	R.Krishnan, “Electric Motor Drives: Modeling Analysis: Modeling, Analysis, and Control”, 1st Edition, Pearson Education India, New Delhi, 2015

	COURSE OUTCOMES: On completion of the course, the students will be able to	**BT Mapped (Highest Level)**
CO1	Explain the fundamentals of DC motor and mathematical knowledge of DC machine	Understanding (K2)
CO2	Categorize power supplies for generic load and machine loads.	Analyzing (K4)
CO3	Examine the operation of closed loop control of converter fed DC drives	Analyzing (K4)
CO4	Compute the performance of VSI and CSI fed AC drives	Applying (K3)
CO5	Design a closed loop motor drive system with controllers for the current and speed control operations.	Applying (K3)

Mapping of COs with POs and PSOs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	2	2	3
CO2	3	3	3
CO3	3	3	3
CO4	3	3	3
CO5	2	2	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	50	20				100
CAT2	30	30	20	20			100
CAT3	30	30	20	20			100
ESE	30	40	20	10			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20PET23 – MODELING AND ANALYSIS OF ELECTRICAL MACHINES

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	20AMT14	2	PC	3	1	0	4

Preamble	The objective of the course is to derive, model and analysis of various DC, AC and permanent magnet machines. Apply various transformation techniques and reference frame theories to simplify the machine models.	
Unit - I	**Generalized Machine Theory**	**9+3**
Essential of Rotating Electrical Machines – Conventions – The Basic Two Pole Machine – Invariance of Power – MMF Distribution of DC and AC Machines – Transformations from Three Phase to Two Phase – Kron's Primitive Machine – Restriction of the Generalized Theory of Electrical Machines – Applications.		
Unit - II	**Modeling of DC Machines**	**9+3**
Theory of Operation – Induced EMF – Equivalent Circuit – Electromagnetic Torque – Field Excitation- Steady State and Transient Analysis of DC Machine – Separately Excited Motor – Shunt Motor – Series Motor – Compound Motor.		
Unit - III	**Modeling of Reluctance and Permanent Magnet Machines**	**9+3**
Synchronous Reluctance Motor - Voltage Equation of Single Phase and Three Phase Synchronous Reluctance Motor - Permanent Magnet Synchronous Motor (PMSM) –– PMSM Voltage Equation in Machine Variables – Permanent Magnet DC Motor – Modeling of Permanent Magnet DC Motor.		
Unit - IV	**Modeling of Induction Machines**	**9+3**
Three Phase Induction Motor – Voltage and Torque Equation in Machine Variables – Reference Frame Theory – Voltage and Torque Equation in Arbitrary Reference Frame – Voltage and Torque Equation in Synchronous Reference Frame – Model Parameter Identification – Steady State and Transient Analysis of Three Phase Induction Motor.		
Unit - V	**Modeling of Synchronous Machines**	**9+3**
Three Phase Synchronous Motor – Voltage and Torque Equations in Machine Variables – Voltage Equation in Rotor Reference Frame – Model Parameter Identification - Steady State and Transient Analysis of Three Phase Synchronous Motor.		

Lecture:45, Tutorial:15, Total:60

REFERENCES:

1	P S Bimbhra, "Generalized Theory of Electrical Machines", 6th Edition, Khanna Publishers, New Delhi, 2018.
2	Paul C Krause, "Analysis of Electric Machinery and Drive Systems", 3rd Edition, McGraw Hill Book Company, New Delhi, 2013.
3	Charles Kingsley Jr., A.E. Fitzgerald and Stephen D.Umans, "Electric Machinery", 7th Edition, McGraw-Hill Higher Education, New York, 2017.
4	Slobodan N. Vukosavic, "Electrical Machines", Springer, Switzerland AG , 2012.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	understand the fundamentals of mathematical modeling and its application	Understanding (K2)
CO2	derive the non-linear mathematical equation and analysis the dc shunt, series and compound motors	Applying (K3)
CO3	derive the mathematical equation for reluctance and permanent magnet motor	Applying (K3)
CO4	apply various reference frame theories and transformation techniques to three phase induction motor	Applying (K3)
CO5	derive the non-linear mathematical equations for three phase synchronous motor	Applying (K3)

Mapping of COs with POs and PSOs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	2	1	
CO2	3	2	1
CO3	3	2	1
CO4	3	2	1
CO5	3	2	1
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	40	30	10			100
CAT2	20	50	20	10			100
CAT3	20	50	20	10			100
ESE	20	50	20	10			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20PET24 – DISTRIBUTED GENERATION

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	2	PC	3	0	0	3

Preamble	This course is designed to impart knowledge about the planning and operational issues related to Distributed Generation	
Unit - I	**Introduction**	**9**
Energy Sources and their availability -trends in energy consumption - Conventional power generations – Energy crises – Non Conventional Energy resources : Review of Solar PV and Wind Energy Systems – Fuel cells – Micro turbines – Biomass – Tidal sources, energy storage systems: batteries – ultra capacitors – fly wheels – captive power power plants.		
Unit - II	**Need for Distributed generation**	**9**
Renewable sources in distributed generation-current scenario in Distributed Generation- IEEE 1547 Standard for interconnecting distributed generation to electric power systems- Planning of DGs – Siting and sizing of DGs – optimal placement of DG sources in distribution regulatory issues.		
Unit - III	**Grid integration of DGs**	**9**
Basic requirements of grid interconnections – operational parameters – voltage, frequency and THD limits Different types of interfaces - Inverter based DGs and rotating machine based interfaces - Aggregation of multiple DG units.		
Unit - IV	**Technical impacts of DGs**	**9**
Transmission systems, Distribution systems, De-regulation – Impact of DGs upon protective relaying and islanding issues in existing distribution grid – Impact of DGs upon transient and dynamic stability of existing distribution systems		
Unit - V	**Economic and control aspects of DGs**	**9**
Market facts, issues and challenges - Limitations of DGs. Voltage\ control techniques, Reactive power control, Harmonics, Power quality issues. Reliability of DG based systems – Steady-state and Dynamic analysis.		

Lecture: 45, Total: 45

REFERENCES:

1. G.B. Gharehpetian, S. Mohammad Mousavi Agah , “Distributed Generation Systems: Design, Operation and Grid Integration”, 1st Edition, Elsevier, 2017
2. Fainan Hassan and Math H. J. Bollen, “Integration of Distributed Generation in the Power System”, 1st Edition, John Wiley and Sons, 2011.
3. H. Lee Willis, Walter G. Scott, “Distributed Power Generation – Planning and Evaluation”, Marcel Decker Press, 2000.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	understand the basics of energy sources and energy storage systems	Understanding (K2)
CO2	Understand the current scenario of Distributed Generation and the need to implement DG sources	Understanding (K2)
CO3	investigate the different types of interfaces for Grid integration of DGs.	Applying (K3)
CO4	explain the technical impacts of DGs upon transmission and distribution systems	Applying (K3)
CO5	evaluate the various control aspects and techniques of different distributed generation sources.	Applying (K3)

Mapping of COs with POs and PSOs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	2		2
CO2	3		2
CO3	3		3
CO4	3	2	3
CO5	3	2	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	70					100
CAT2	30	60	10				100
CAT3	30	50	20				100
ESE	30	50	20				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20PEL21 – SOLID STATE DRIVES AND CONTROL LABORATORY

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	2	PC	0	0	2	1
Preamble	To get exposure about the DC and AC drives and their speed control techniques.						

List of Exercises / Experiments :

1.	Simulation of open and closed loop control of converter fed DC motor
2.	Simulation of open and closed loop control of chopper fed DC motor
3.	Simulation for Modelling and Testing of Induction Motor
4.	Simulation of VSI fed Three phase induction motor
5.	Speed control of DC motor using Three phase Rectifier
6.	Speed control of Three phase induction motor using PWM inverter
7.	FPGA based drive for induction motor
8.	DSP based chopper drive for DC Motor(Programming and Implementation)
9.	
10.	
11.	
12.	

Practical : 30,Total: 30

REFERENCES/MANUAL/SOFTWARE:

1.	MATLAB software
2.	Laboratory Manual

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	Examine the performance of DC and AC drives using software tool	Applying (K3), Manipulation (S2)
CO2	Demonstrate the speed control of DC and AC motor using conventional techniques	Applying (K3), Manipulation (S2)
CO3	Execute the modern digital control techniques for the speed control of DC motor and AC motor	Applying (K3), Manipulation (S2)

Mapping of COs with POs and PSOs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

20PEP21 - INNOVATIVE PROJECT

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	2	EC	0	0	4	2

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1	Identify a real world problem and develop the design solutions	Applying (K3)
CO2	Select the proper components as per requirements of the design/system	Applying (K3)
CO3	Apply the new tools, algorithms, methodologies that contribute to obtain the solution of the project	Analyzing (K4)
CO4	Analyze the findings and execute the project with developed prototype as a team	Analyzing (K4)
CO5	Defend the findings and conclude with oral/written reports.	Evaluating (K5)

Mapping of COs with POs and PSOs			
COs/POs	PO1	PO2	PO3
CO1	3	3	3
CO2	3	3	3
CO3	3	3	3
CO4	3	3	3
CO5	3	3	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

20PEP31 - INTERNSHIP CUM PROJECT WORK

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	3	EC	0	0	18	9

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1	Identify a real world problem and develop the design solutions	Applying (K3)
CO2	Select the proper components as per requirements of the design/system	Applying (K3)
CO3	Apply the new tools, algorithms, methodologies that contribute to obtain the solution of the project	Analyzing (K4)
CO4	Analyze the findings and execute the project with developed prototype as a team	Analyzing (K4)
CO5	Defend the findings and conclude with oral/written reports.	Evaluating (K5)

Mapping of COs with POs and PSOs			
COs/POs	PO1	PO2	PO3
CO1	3	3	3
CO2	3	3	3
CO3	3	3	3
CO4	3	3	3
CO5	3	3	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

20PEP41 - PROJECT WORK 2

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	4	EC	0	0	18	9

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1	Identify a real world problem and develop the design solutions	Applying (K3)
CO2	Select the proper components as per requirements of the design/system	Applying (K3)
CO3	Apply the new tools, algorithms, methodologies that contribute to obtain the solution of the project	Analyzing (K4)
CO4	Analyze the findings and execute the project with developed prototype as a team	Analyzing (K4)
CO5	Defend the findings and conclude with oral/written reports.	Evaluating (K5)

Mapping of COs with POs and PSOs			
COs/POs	PO1	PO2	PO3
CO1	3	3	3
CO2	3	3	3
CO3	3	3	3
CO4	3	3	3
CO5	3	3	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

20PEE01 – OPTIMIZATION TECHNIQUES

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	1	PE	3	0	0	3

Preamble	This course is aimed to introduce the fundamental concepts and techniques of optimization to solve engineering problems by developing suitable mathematical models	
Unit - I	**Linear Programming**	**9**
Definition **-** Optimization problems **-** Revised simplex method **-** Duality in linear programming **-** Dual simplex method **–** Sensitivity analysis.		
Unit - II	**Non-Linear Programming (Unconstrained Optimization)**	**9**
Direct search methods **-** Univariate method **-** Pattern search method **-** Simplex method **-** Descent methods **-** Steepest Descent method**-** Conjugate gradient method **-** Quasi Newton method.		
Unit - III	**Non-Linear Programming (Constrained Optimization)**	**9**
Direct methods **-** The Complex method **-** Zoutendijk's Method of Feasible Directions **-** Rosen's Gradient Projection Method. Indirect method - Transformation Techniques - Basic Approach of the Penalty Function Method - Interior Penalty Function Method - Exterior Penalty Function Method.		
Unit - IV	**Dynamic Programming**	**9**
Multistage decision process - Sub optimization and Principle of Optimality, Computational procedure - Final value problem to initial value problem - Linear Programming as a Case of Dynamic Programming - Continuous dynamic programming.		
Unit - V	**Modern Methods of Optimization**	**9**
Genetic algorithm **–** Simulated annealing **-** Particle Swarm Optimization **-** Ant Colony Optimization – Neural Network Based Optimization – Application to power electronics.		

Lecture: 45, Total: 45

REFERENCES:

1. S.S. Rao, "Engineering Optimization – Theory and Practice", 4th Edition, John Wiley & Sons, New Jersey,2009
2. Sharma J K, "Operations Research: Theory and Applications", 5th Edition, Macmillan Company, New Delhi,2013
3. Gupta C B, "Optimization Techniques in Operations Research", 2nd Edition, I K International Pvt. Ltd, New Delhi,2013

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	Understand the basic concepts of optimization techniques and apply linear programming for solving engineering problems	Applying(K3)
CO2	Apply nonlinear unconstrained optimization for solving engineering problem	Applying(K3)
CO3	Apply nonlinear constrained optimization for solving engineering problem	Applying(K3)
CO4	Apply dynamic programming for obtaining optimal value for real world problem	Applying(K3)
CO5	Apply modern optimization algorithm to solve real world problems and analyze various performance measures	Analyzing(K4)

Mapping of COs with POs and PSOs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	3		2
CO2	3		2
CO3	3		2
CO4	3		2
CO5	3		3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	60	10				100
CAT2	30	60	10				100
CAT3	30	50	10	10			100
ESE	30	50	10	10			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20PEE02 – PROGRAMMABLE LOGIC CONTROLLERS

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	1	PE	3	0	0	3

Preamble	The aim of the subject is to develop an understanding of the basic concepts of automation system using Programmable logic Controller	
Unit - I	**Introduction**	**9**
Overview of Programmable Logic Controller - Architecture – Principle of operation - I/O Modules: Discrete, Analog, Special – I/O Specifications – CPU – Memory design and types – Programming devices – Recording and Retrieving data –PLC programming languages.		
Unit - II	**Basic PLC Programming**	**9**
Fundamentals of Logic – Program Scan– Relay-Type Instructions - Instruction addressing – Branch and Internal relay instructions – Entering the Ladder diagram – Electromagnetic Control relays – Contactors – Motor Starters – Manual operated switches and Mechanically operated switches.		
Unit - III	**Advanced PLC Programming**	**9**
Programming Timers – Programming Counters – Program Control Instructions – Data Manipulation Instructions – Math Instructions – Sequencer and Shift Register Instructions.		
Unit - IV	**PLC Installation and Troubleshooting**	**9**
PLC Enclosures – Electrical Noise – Leaky Inputs and Outputs – Grounding – Voltage Variations and Surges – Program Editing – Programming and Monitoring – Preventive Maintenance – Connecting PC and PLC.		
Unit - V	**PLC Communication and its Applications**	**9**
Computer Fundamentals – Computer-Integrated Manufacturing – Data Communication - Simple materials handling applications, Automatic control of warehouse door, Automatic lubrication of supplier Conveyor belt, motor control, Automatic car washing machine, Bottle label detection and process control application.		

Lecture: 45, Total: 45

REFERENCES:

1. Frank D. Petruzella, “Programmable Logic Controllers”, 3rd Edition, Tata McGraw-Hill Edition, New Delhi, 2014.
2. Webb John W. and Reis Ronald A., “Programmable Logic Controllers”, 5th Edition, Prentice Hall Publications, New Delhi, 2005.
3. Bolton W., “Programmable Logic Controllers”, 4th Edition, Elsevier, New York, 2006.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	identify the PLC hardware and programming languages for various applications	Applying(K3)
CO2	develop PLC ladder logic programming for industrial problems	Applying(K3)
CO3	design a PLC system, component, or process to meet a set of specifications	Applying(K3)
CO4	install and troubleshoot the PLC	Analyzing(K4)
CO5	apply the PLC in various industrial applications	Applying(K3)

Mapping of COs with POs and PSOs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	3	1	2
CO2	3	1	3
CO3	3	1	3
CO4	3		3
CO5	3		3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	70					100
CAT2	30	50	20				100
CAT3	30	50	10	10			100
ESE	30	50	10	10			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20PEE03 – VIRTUAL INSTRUMENTATION FOR INDUSTRIAL APPLICATIONS

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	1	PE	3	0	0	3

Preamble	This course will provide foundation to familiarize with virtual instrumentation techniques to find solutions to real time industrial applications	
Unit - I	**Introduction to Virtual Instrumentation**	**9**
Graphical System Design (GSD) Model- Virtual and Traditional instrument- hardware and software in VI- VI for test, control and design. **Introduction to LabVIEW**: software environment-palettes- data type- data flow program.		
Unit - II	**LabVIEW Programming Basics I**	**9**
Modular programming in LabVIEW**-** creating icon- connector pane- VI and sub VI - FOR and WHILE loops- case, sequence structures, event structures- shift registers- control timings-formula nodes- communication among multiple loops- local and global variables.		
Unit - III	**LabVIEW Programming Basics II**	**9**
Arrays:1D- 2D arrays- array functions- matrix operation with arrays, Clusters: controls and indicators- constant- operation- conversion between array and cluster- error handling. String: controls and indicators- functions- formatting – configuring string. File: high and low level file I/O -waveform graph and chart operations.		
Unit - IV	**Data Acquisition System**	**9**
GPIB communication- hardware specification- software architecture-VISA- instrument drivers- serial port communication. review of transducer and signal conditioning- DAQ hardware- analog inputs- analog outputs- digital inputs /outputs- DAQ assistant		
Unit - V	**Industrial Applications of VI**	**9**
Industrial Embedded Monitoring and Control of Manufacturing Equipment - Industrial Embedded Equipment Control VAR Compensator- Remotely Monitoring Electrical Power Signals with a Single-Board RIO- material handling system- plastic injection and molding system-semiconductor production and control system.z		

Lecture: 45, Total: 45

REFERENCES:

1.	Jovitha Jerome, “Virtual Instrumentation using LabVIEW”, 3rd Edition, PHI Learning Pvt. Ltd.,New Delhi, 2012
2.	S.Sumathi, P.Surekha, “LabVIEW based Advanced Instrumentation Systems”, Springer Science & Business Media, 2007
3.	Sanjay Gupta, Joseph, John, “Virtual Instrumentation using LabVIEW”, 2nd Edition, Tata McGraw Hill, New Delhi, 2010

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	explain the Virtual Instrumentation Working environmental	Understanding (K2)
CO2	apply structured programming concepts in developing LabVIEW programs	Applying (K3)
CO3	design, implement and analyze an application using different tools	Applying (K3)
CO4	interface DAQ system with LabVIEW	Applying (K3)
CO5	design VI system for real time applications	Applying (K3)

Mapping of COs with POs and PSOs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	1		
CO2	2	2	
CO3	3	2	1
CO4	3		1
CO5	3	1	2
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	50	50					100
CAT2	20	40	40				100
CAT3	20	40	40				100
ESE	20	40	40				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20PEE04 – SCADA AND DCS

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	1	PE	3	0	0	3

Preamble	The aim of the subject is to develop an understanding of the basic concepts of automation system using SCADA and DCS, programming with SCADA systems, comparison of PLC with DCS, DCS with SCADA and to develop the automation system in industrial applications using SCADA and DCS.	
Unit - I	**Automation**	**9**
Fundamentals of industrial automation, need and role of automation, evolution of automation. HMI systems, Text display – operator panels – Touch panels – Panel PCs – Integrated displays (PLC & HMI), Rack installation, Grounding and shielding, physical, electrical, maintenance requirements-Troubleshooting.		
Unit - II	**SCADA**	**9**
Concept of SCADA systems, Programming techniques for : Creation of pages, Sequencing of pages, Creating graphics & animation, Dynamos programming with variables, Trending, Historical data storage & Reporting, Alarm management, reporting of events and parameters. Comparison of different SCADA packages. Application Development using SCADA system.		
Unit - III	**Distributed Control System**	**9**
DCS - Various Architectures: Hybrid, Central Computers, Distributed architectures - Comparison - Local control unit - Architectures - Process interfacing issues- Redundant Controller Designs- Process Input/ Output Design Issues.		
Unit - IV	**Interfaces in DCS**	**9**
Operator interfaces - Low level and high level operator interfaces - Displays - Engineering interfaces - Low level and high level engineering interfaces - Factors to be considered in selecting DCS – Interfacing of DCS with electrical MCC- Case studies in DCS- Control of Mixing unit in Cement industries- Automatic elevator control.		
Unit - V	**Applications**	**9**
Applications of SCADA & DCS – Case studies of Process plants using SCADA & DCS – Advanced features / options in SCADA & DCS – Role of PLC in DCS and SCADA – comparison – field devices (Transducers, drives etc) in DCS / SCADA.		

Lecture: 45, Total: 45

REFERENCES:

1. Lukas, Michael P., “Distributed Control Systems - Their Evaluation and Design”, 2nd Edition, Van Nostrand Reinfold Company, 2002.
2. Benjamin C Kuo, “Automatic Control Systems”, 9th Edition, Willey,2012
3. Dobrivojie Popovic, Vijay P. Bhatkar, “Distributed Computer Control for Industrial Automation”, CRC Press, 1990

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	demonstrate the basic concepts on automation system	Understanding (K2)
CO2	develop programming with SCADA system	Applying (K3)
CO3	explain the basic concepts of DCS	Applying (K3)
CO4	develop a DCS system and interface with other processes to meet a set of specifications	Applying (K3)
CO5	apply the SCADA and DCS in various industrial applications	Applying (K3)

Mapping of COs with POs and PSOs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1		3	
CO2	2		3
CO3		3	
CO4	3		3
CO5	3		3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	70					100
CAT2	30	50	20				100
CAT3	30	50	20				100
ESE	30	50	20				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20PEE05 – POWER ELECTRONICS FOR SOLAR AND WIND ENERGY CONVERSIONS

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	2	PE	3	0	0	3

Preamble	The objective of the course is to impact knowledge about the need for power electronics in for solar and wind energy conversion systems, converters, inverters, hybrid systems.	
Unit - I	**Analysis of Solar Energy**	**9**
Energy sources and their availability - impacts of renewable energy generation on environment (cost-GHG Emission) - Photovoltaic Energy Conversion and applications: Solar radiation and measurement - Solar cells and their characteristics - Influence of insolation and temperature - PV arrays - Introduction to flexible solar cells - Electrical storage with batteries.		
Unit - II	**Solar Energy Conversion and Applications**	**9**
Block diagram of solar photo voltaic system - Switching devices for solar energy conversion – Array sizing- Boost and buck boost converters, SEPIC, Cuk, Zeta converters - battery sizing - Selection of inverter – Stand alone inverters - Charge controllers - Water pumping and Street lighting-Grid integrated solar system - Analysis of PV Systems.		
Unit - III	**Analysis of Wind Energy**	**9**
Basic Principle of wind Energy conversion - Nature of Wind - Power in the wind - Components of Wind Energy Conversion System (WECS) - Performance of Induction Generators for WECS -Classification of WECS - Wind farm and its accessories		
Unit - IV	**Wind Energy Conversion**	**9**
Self Excited Induction Generator (SEIG) for isolated Power Generators - Theory of self excitation - Capacitance requirements - Controllable DC Power from SEIGs - Grid connectors concepts - Grid related problems - Generator control - Performance improvements - Different schemes - AC voltage controllers-AC-DC-AC converters: uncontrolled rectifiers,PWM Inverters, Grid Interactive Inverters-matrix converters.		
Unit - V	**Hybrid Systems and Power Converters**	**9**
Need for Hybrid systems-Wind / Solar PV integrated systems - Selection of power conversion ratio - Optimization of system components - Storage - Reliability evolution - Power conditioning schemes: DC Power conditioning Converters - Maximum Power point tracking algorithms - AC Power conditioners - Line commutated inverters - Synchronized operation with grid supply-Grid interactive inverters.		

Lecture: 45, Total: 45

REFERENCES:

1. Chetan Singh Solanki, “Solar Photovoltaics : Fundamentals, Technologies and Applications”, 2nd Edition, PHI Learning Pvt. Ltd., New Delhi 2011.
2. Daniel, Hunt, V., "Wind Power - A Handbook of WECS", 1st Edition, Van Nostrend Co., New York, 1998.
3. B.H.Khan, " Non-conventional Energy sources", 2nd Edition, Tata McGraw-hill Publishing Company, New Delhi,2009.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	outline the impact of green energy sources and basic characteristics, working PV cells	Understanding (K2)
CO2	explain the switching devices used in applications of PV cells	Understanding (K2)
CO3	acquire knowledge on of fundamental of wind power, detailed model of the Wind Energy components and its control systems	Understanding (K2)
CO4	Determine the power electronic devices employed in wind energy applications	Applying (K3)
CO5	summarize stand - alone systems and Grid connected systems	Understanding (K2)

Mapping of COs with POs and PSOs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	3	2	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	2	1
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	40	60					100
CAT2	40	60					100
CAT3	10	60	30				100
ESE	40	60					100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20PEE06 – ADVANCED POWER CONVERTERS

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	2	PE	3	0	0	3

Preamble	To give an introduction to the recent developments in the power electronics converters. This course introduces the advanced power converters such as Self Lift, Super Lift and Ultra lift converters. It also deals with the synchronous rectifiers and cascaded boost converters.	
Unit - I	**Voltage-Lift Converters**	**9**
Introduction- Self-lift and reverse self-lift circuits- Cuk converter, Luo converter and SEPIC converters- continuous and discontinuous conduction mode.		
Unit - II	**Positive Output & Negative Output Super-Lift Luo converters**	**9**
Main series, -Elementary Circuit, Re-Lift Circuit, Triple-Lift Circuit, Higher-Order Lift Circuit- Continuous conduction and discontinuous conduction mode.		
Unit - III	**Ultra Lift Converters and Multiple-Quadrant operating Luo-Converters**	**9**
Ultra-Lift Luo- Converter- Operation - Continuous conduction and discontinuous conduction Mode and of Ultra-Lift Luo-Converter-Instantaneous Values- Multiple quadrant operating Luo Converters- Circuit explanations - modes of operation		
Unit - IV	**Cascaded Boost Converters**	**9**
Positive output cascaded boost converters and negative output cascaded boost converters – Main series – Elementary – Two-stage – Three-stage and Higher stage.		
Unit - V	**Synchronous rectifier DC/DC converters**	**9**
Introduction **-** Synchronous rectifier Luo converter – Flat transformer and active clamped circuits – Transformer is in magnetizing process – Switching on - Transformer is in demagnetizing process – Switching off		

Lecture: 45, Total: 45

REFERENCES:

1. Fang Lin Luo, Hong Ye, “Advanced DC/DC Converters”, 2nd Edition, CRC press, 2018
2. Fang Lin Luo, Hong Ye, “Essential DC/DC Converters”, 1st Edition, CRC, 2005
3. Fang Lin Luo, Hong Ye, “Power Electronics Advanced Conversion Technologies”, 2nd Edition, CRC press, 2018

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	explain the working principle of self lift voltage converters	Understanding (K2)
CO2	explain the principle of operation of super lift voltage converters	Applying (K3)
CO3	outline the working principle of ultra lift voltage converters	Understanding (K2)
CO4	outline the principle of operation of cascaded boost converters	Understanding (K2)
CO5	explain the principle of operation of synchronous rectifier DC/DC converters	Understanding (K2)

Mapping of COs with POs and PSOs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	2	1	3
CO2	3	1	3
CO3	2	1	3
CO4	2	1	3
CO5	2	1	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	70					100
CAT2	30	60	10				100
CAT3	30	70					100
ESE	30	60	10				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20PEE07 – COMPUTER AIDED DESIGN OF ELECTRICAL MACHINES

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	2	PE	3	0	0	3

Preamble	The objective of the course is to identify the design parameter for electromechanical system using various standard design procedures and development constrain. Apply finite element method and CAD package to design and analysis of various electromechanical systems.	
Unit - I	**Fundamental Aspects and Materials**	**9**
Introduction – Design Factor – Limitations in Design –- Electric Conductivity and Resistivity Material – Magnetic Material – Insulating Material – Permanent Magnet and Characteristics - Modern Manufacturing Practices		
Unit - II	**Principles of Magnetic and Thermal Design**	**9**
Fundamental of Magnetic Circuit – Magnetizing Curve – Real and Apparent Flux Density – Determination of Iron Loss – Determination of Copper Loss by Considering Skin and Proximity Effects – Modes of Heat Dissipation – Cooling Strategies		
Unit - III	**Design of DC Motor**	**9**
Constructional Details – Choice of Flux Density and Ampere Conductor – Main Dimension – Poles and Slots- Armature Windings - Design of Field and Armature System – Design of Commutator and Brushes		
Unit - IV	**Design of AC Motor**	**9**
Constructional Details: Induction Motor (IM), Synchronous Reluctance Motor (SYNRM) and Permanent Magnet Synchronous Motor (PMSM) - Choice of Flux Density and Ampere Conductor – Main Dimension – Three Phase Distributed Windings - Stator Design and Rotor Design: IM, SYNRM and PMSM – Length of Air Gap – Design of Shaft		
Unit - V	**Finite Element Modeling and Analysis using ANSYS Software**	**9**
Maxwell's Equation - Preprocessing - Meshing - Material Assigning - Boundary Conditions - Setting up Solution – Post processing – Design of DC Motor - Induction Motor – Permanent Magnet Synchronous Motor.		

Lecture: 45, Total: 45

REFERENCES:

1.	A. K. Sawhney, "Electrical Machine Design", 3rd Edition, Dhanpat Rai & Co, New Delhi, 2017.
2.	M. G. Say, "The Performance and Design of Alternating Current Machines", 3rd Edition, CBS, New Delhi, 2002.
3.	Hendershot JR, Miller TJE, "Design of Brushless Permanent Magnet Motors", Motor design book LLC, Venice, 2010.
4	Juha Pyrhonen, Tapani Jokinen and Valeria Hrabovcova, "Design of Rotating Electrical Machines", 2nd Edition, John Wiley & Sons, New Delhi, 2013.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	classify and compare the various fundamental aspects and materials used for electrical machines	Understanding (K2)
CO2	illustrate the principles of magnetic and thermal design for various electrical machines	Understanding (K2)
CO3	identify the design parameter of DC motor by considering load requirement	Applying (K3)
CO4	identify the design parameter of AC motor by considering load requirement	Applying (K3)
CO5	design and finite element analysis of various electrical machines using ANSYS software	Analyzing (K4)

Mapping of COs with POs and PSOs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	2	1	
CO2	2	1	
CO3	3	2	1
CO4	3	2	1
CO5	2	3	2
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	50	30				100
CAT2	20	50	30				100
CAT3	20	50	20	10			100
ESE	20	50	20	10			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20PEE08 – POWER QUALITY ENGINEERING

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	2	PE	3	0	0	3

Preamble	The objective of the course is to provide knowledge about various power quality problems, effects and improvement techniques.	
Unit - I	**Power Quality Definitions, Wiring & Grounding**	**9**
Power Quality Definitions**:** Introduction – Power Quality definitions: Transients, Short and Long Duration Voltage variations, Power frequency disturbances: curves for low frequency disturbances - power acceptability curves (CBEMA and ITI). **Wiring, Grounding:** Wiring, Grounding: Definitions- National Electrical Code for Grounding Requirements - Reasons for grounding. Typical Wiring and grounding problems, Solutions to wiring and grounding problems.		
Unit - II	**Waveform Distortions**	**9**
Harmonics: Voltage imbalance, Waveform distortion, Voltage fluctuations. Harmonic indices, inter-harmonics, flicker, Harmonic sources from commercial and industrial, Standards on harmonics. System response characteristics: System impedance, capacitor impedance, parallel resonance, series resonance loads, effects of resistance and resistive load. Effects of harmonic distortion: Impact on capacitors, transformers, motors and telecommunication circuits – Guidelines for voltage and current harmonics limitations.		
Unit - III	**Waveform Processing Techniques and Monitoring**	**9**
Fundamental frequency characterization: Curve – fitting algorithm, implementation, frequency estimation, R.M.S Error assessment, Fourier analysis: Convolution of harmonic phasors, sampled time functions, DFT, Efficiency of FFT algorithms, Wavelet transform, automation of disturbance reorganization.		
Unit - IV	**V-sag Economics & PQ Measurement Equipment**	**9**
Voltage sag Economics: Sources of Sag – Estimating voltage sag performance, Evaluating the harmonics of different ride-through alternatives, PQ insurance: Overview of concept, Designing an insurance policy. Power Quality Measurement Equipment**:** Types of instruments, wiring and grounding testers, disturbance analyzers, spectrum and harmonic analyzer, flicker meter, smart power quality monitor – number of test locations – test duration of measurement.		
Unit - V	**Power Quality Assessment, Improvement and Harmonic Filters**	**9**
Assessment of power quality measurement data: Off – line, On – line data assessment, Application of Intelligent systems – Active, Passive and Hybrid filters. Custom power Devices: Network reconfiguring devices, Load compensation using DSTATCOM, Voltage regulation using DSTATCOM, protecting sensitive loads using DVR, UPQC. Control strategies: P – Q theory, Synchronous detection method.		

Lecture: 45, Total: 45

REFERENCES:

1. Dugan C. Roger, “Electrical Power Systems Quality”, 3rd Edition,Tata McGraw Hill, New Delhi, 2012.
2. Arillaga J., “Power System Quality Assessment”, 1st Edition, Wiley India Pvt. Ltd., New Delhi, 2011.
3. Sankaran C., “Power Quality”, 1st Edition, CRC Press, New York, 2011.

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1	identify the concepts of different power quality definitions, codes and grounding problems	Understanding (K2)
CO2	classify the types of waveform distortions and its impact on various loading condition	Understanding (K2)
CO3	apply different waveform processing techniques for power quality improvement	Applying (K3)
CO4	explain the sag economics and different types of PQ measuring instruments	Understanding (K2)
CO5	assess the power quality using filters and custom power devices	Analyzing (K4)

Mapping of COs with POs and PSOs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	3	1	2
CO2	2	2	2
CO3	3	1	2
CO4	2	2	2
CO5	3	2	2
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	70					100
CAT2	30	50	20				100
CAT3	30	50	20				100
ESE	30	50	20				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20PEE09 – CONTROL DESIGN TECHNIQUE FOR POWER ELECTRONICS SYSTEMS

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	2	PE	3	0	0	3

Preamble	This course is designed to impart knowledge about the operation of different types of design techniques for Power Electronics System.	
Unit - I	**Switch Realization and Switching Loss Calculation**	**9**
Review of Quadrant operation of Ideal Switches: Diode, Thyristor, BJT, IGBT, MOSFET and TRIAC-Realization of Semiconductor switch for one quadrant operation, Current bidirectional operation, Voltage bidirectional operation, four quadrant operation- Thermal Design of Power Switching Devices-Estimation of loss in switch: Conduction Loss-Switching Loss –Blocking Loss- Transistor Switching with Clamped Inductive Load		
Unit - II	**Design of Magnetics**	**9**
Basic magnetic theory revision – Inductor design – Design of mutual inductance – Design of transformer for isolated topologies – Ferrite core table and selection of area product–wire table–selection of wire gauge.		
Unit - III	**Converter Dynamics**	**9**
AC equivalent circuit analysis–State space averaging–Circuit averaging–Averaged switch modeling–Transfer function model for buck, boost, buck-boost and cuk converters–Input filters.		
Unit - IV	**Compensator Design and Current Mode Control**	**9**
Closed loop requirements-Compensator structure-Design of compensator-Introduction of Current Mode Control-Block diagram of Current Mode Control-Advantages of Current Mode control		
Unit - V	**Controller Design**	**9**
Review of P, PI, and PID control concepts–gain margin and phase margin–Bode plot based analysis–Design of controller for buck, boost, buck-boost and cuk converters.		

Lecture: 45, Total: 45

REFERENCES:

1. Ned Mohan, Tore M. Undeland and William P.Riobbins, “Power Electronics - Converters, Applications and Design”, 3rd Edition, John Wiley and Sons Inc, Canada,2014
2. Muhammad H. Rashid, “Power Electronics, Circuits, Devices and Application”,4th Edition, Pearson Education India,New Delhi,2013
3. Sira-Ramirez, Hebertt, Silva-Ortigoza, Ramón, “Control Design Techniques in Power Electronics Devices”, 1st Edition, Springer, London, 2006

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	Determine the switching losses of power switching devices	Applying (K3)
CO2	Examine the operation of protection circuits and firing circuits for different switching devices	Analyzing (K4)
CO3	Design a magnetics for power converter applications	Applying (K3)
CO4	Derive transfer function of different converters	Analyzing (K4)
CO5	Design controllers for DC to DC converters	Applying (K3)

Mapping of COs with POs and PSOs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	2	2	2
CO2	3	3	3
CO3	3	3	3
CO4	3	3	3
CO5	3	3	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	50	20				100
CAT2	30	30	20	20			100
CAT3	30	30	20	20			100
ESE	30	40	20	10			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20PEE10 – RESONANT CONVERTERS

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	2	PE	3	0	0	3

Preamble	To impart knowledge on resonant converter and its control circuit based on dynamic analysis.	
Unit - I	**Review on Parallel and Series Resonant Switches**	**9**
Introduction –classification – ZV and ZC resonant switch–Sinusoidal Analysis of Resonant Converters – Resonant Tank network circuits - Series and Parallel Resonant DC–DC Converter–LCC type converter– Small signal analysis (phasor and spectral analysis) – design of series and parallel resonant DC-DC converter.		
Unit - II	**State Plane analysis and Soft Switching Techniques**	**9**
Fundamentals of state–plane and averaged analysis of resonant circuits – Analysis of ringing and switching loss in PWM converters – analysis of the series resonant converter with CCM and DCM. Soft Switching :Introduction –comparison of hard switched and soft switched converters–Operation of the Full Bridge Below Resonance – Zero Current Switching - Operation of the Full Bridge Above Resonance – Zero Voltage Switching- Load Dependent I/Ocharacteristics of Resonant Converters.		
Unit - III	**Quasi Resonant Converters**	**9**
Introduction – Family of QRC –Classification of Quasi resonant switches–ZCS and ZVS quasi-resonant converters:State-plane analysis–Characteristics–Averaged modeling of converter dynamics. Quasi-square-wave converters–ZVS and ZCS topologies–Waveforms and characteristics.Zero-voltage transition converters– Characteristic waveforms–Phase control. Introduction to Multiresonant converter.		
Unit - IV	**Analysis of QRC family**	**9**
Zero Current Switching of Quasi Resonant Buck converter– Zero Current Switching of Quasi Resonant Boost converter– Zero Voltage Switching of Quasi Resonant Buck converter– Zero Voltage Switching of Quasi Resonant Boost converter –Zero Current Switching of Quasi Resonant Cuk converter –Zero Voltage Switching of Quasi Resonant Cuk converter		
Unit - V	**Control Circuit and Dynamic Analysis**	**9**
Control circuit for RC and QRC –Voltage Mode PWM Scheme–Current Mode PWM Scheme – Review of linear system analysis–State Space Averaging–Basic State Space Average Model State Space Averaged model for Boost and ZETA converter – Sliding Mode Controller – Fundamentals – Basics of control law design – stability analysis of DC Buck Converter		

Lecture: 45, Total: 45

REFERENCES:

1.	Robert W. Erickson & Dragon Maksimovic, ”Fundamentals of Power Electronics”, 2nd Edition, Springer science and Business media, New York, 2001.
2.	William Shepherd and Li zhang, ”Power Converters Circuits”, CRC Press, 2004
4.	Mehta, Axaykumar, Naik, Brijesh, “Sliding Mode Controllers for Power Electronic Converters”, Springer, 2019

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	understand the working principle of various resonant converters	Understanding (K2)
CO2:	Analyze the concept of soft switching	Applying (K3)
CO3:	Understand the working Quasi resonant Converter	Understanding (K2)
CO4:	outline the ZCS and ZVS techniques employed in resonant converters	Understanding (K2)
CO5:	understand the various control strategies used in resonant converters	Understanding (K2)

Mapping of COs with Pos			
COs/POs	PO1	PO2	PO3
CO1	2	1	3
CO2	3	1	3
CO3	2	1	3
CO4	2	1	3
CO5	2	1	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy			

ASSESSMENT PATTERN							
Test/Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total 100%**
CAT 1	30	70					100
CAT 2	30	60	10				100
CAT 3	30	60	10				100
ESE	30	60	10				100
***±3% may be varied, (CAT1, 2, 3 – 50 marks, ESE – 100 marks)**							

20PEE11 – MICROGRID AND SMART GRID

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	2	PE	3	0	0	3

Preamble	The course content is designed to study about micro grid standalone autonomous system, smart grid technologies, distribution automation, information and communication technologies. It is used to get familiarized with smart metering and control of smart grid systems.	
Unit - I	**Microgrid Concept, Structure and Operating Modes**	**9**
Introduction – Micro Grid Concept and Structure- Operation Modes- Control Mechanism of the Connected DG in a Micro Grid – Micro Grid Operation and Protection Strategies.		
Unit – II	**Microgrid Control**	**9**
Hierarchical Power Management and Control - DC Micro Grid for a Residential Area- Low Voltage Bipolar type DC Micro grid - State Space Model – H Infinity Control Design - µ based Control Design.		
Unit – III	**Smart Grid Architecture and Techniques**	**9**
Introduction to Smart grid – Indian Smart Grid and Challenges - Components and Architecture of Smart Grid Design - Renewable Integration - Smart Grid Demonstration and Deployment Efforts –Indian Smart Grid –Key Challenges for Smart Grid - Static and Dynamic Optimization Techniques **-** Artificial Intelligence techniques.		
Unit – IV	**Distribution Generation Technologies and Communication Technologies**	**9**
Introduction to Renewable Energy Technologies – Storage Technologies –Electric Vehicles and Plug–in Hybrids– Environmental Impact and Climate Change – Economic Issues - Introduction to Communication Technology –Synchrophasor Measurement Units (PMUs) –Wide Area Measurement Systems (WAMS).		
Unit – V	**Control of Smart Power Grid System**	**9**
Load Frequency Control (LFC) in Micro Grid System –Voltage Control in Micro Grid System – Reactive Power Control in Smart Grid. Case Studies and Test beds for the Smart Grids.		

Lecture: 45, Total: 45

REFERENCES:

1.	Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, AkihikoYokoyama, “Smart Grid: Technology and Applications”, 1st Edition, Wiley & Sons Ltd., United States, February 2012.
2.	Hassan Bevrani, Bruno Francois and Toshifumi Ise, ‘Microgrid Dynamics and Control’, 1st Edition , Wiley, United States, 2017.
3.	Stuart Borlase, “Smart Grid: Infrastructure, Technology and Solutions”, 1st Edition , CRC Press, United States, 2012.

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1	Understand the features of micro grid.	Understanding (K2)
CO2	Assess the control aspects of micro grid.	Understanding (K2)
CO3	Analyze the architecture of smart grid and its techniques.	Applying (K3)
CO4	Interpret the communication technology used in smart grid.	Applying (K3)
CO5	Choose the control strategy for smart power grid system.	Applying (K3)

Mapping of COs with POs and PSOs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	2		3
CO2	3		3
CO3	3	2	3
CO4	2		3
CO5	3	2	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	40	60					100
CAT2	30	60	10				100
CAT3	20	60	20				100
ESE	20	40	20				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20PEE12 – ELECTRIC VEHICLE SYSTEMS

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	2	PE	3	0	0	3

Preamble	The aim of the subject is to develop an understanding of the basic concepts, principles, analysis and design electric vehicles. This course goes deeper into the various aspects of electric drive train such as their configuration, types of electric machines that can be used, energy storage devices.	
Unit - I	**Introduction to Electric Vehicles**	**9**
History of electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance.		
Unit - II	**Electric Drive-trains & Sizing the drive system**	**9**
Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis. Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystem		
Unit - III	**Electric Propulsion unit**	**9**
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, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.		
Unit - IV	**Energy Storage**	**9**
Introduction to Energy Storage Requirements in Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices.		
Unit - V	**Energy Management Strategies**	**9**
Introduction to energy management strategies used in electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies.		

Lecture: 45, Total: 45

REFERENCES:

1. Iqbal Hussain., “Electric and Hybrid Vehicles: Design Fundamentals”, 3rd Edition, CRC press, Taylor & Francis Group, Florida, United States, 2021
2. Mehrdad Ehsani, YimiGao, Sebastian E. Gay, Ali Emadi, “Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design”, 3rd Edition, CRC Press, 2018
3. James Larminie, John Lowry, “Electric Vehicle Technology Explained”, 2nd Edition, Wiley, 2003.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	Demonstrate the impact of conventional vehicles on the society and	Understanding (K2)
CO2	Illustrate the different types of drive train topologies and sizing of the drive system	Applying (K3)
CO3	explain the basic concepts of electric propulsion unit with different motor drives	Applying (K3)
CO4	Choose proper energy storage systems for vehicle applications	Applying (K3)
CO5	apply the concept of energy management strategies used in electric vehicles	Applying (K3)

Mapping of COs with POs and PSOs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	2	1	1
CO2	2		3
CO3	2	3	
CO4	3		3
CO5	3		3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	70					100
CAT2	30	50	20				100
CAT3	30	50	20				100
ESE	30	50	20				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20PEE13 – PWM TECHNIQUES AND ITS APPLICATIONS

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	3	PE	3	0	0	3

Preamble	This course brings the fundamentals of pulse width modulation techniques and the various types. It is certainly needed for the development of pulses required for the power converters.	
Unit - I	**Fundamentals of PWM**	**9**
Fundamental Concepts of PWM - Evaluation of PWM Schemes - Double Fourier Integral Analysis of a Two-Level PWM waveform - Naturally Sampled PWM - PWM Analysis by Duty Cycle Variation - Regular Sampled PWM- Direct modulation.		
Unit - II	**Programmed Modulation Strategies**	**9**
Integer versus non integer frequency ratios- Review of PWM variations – Optimized spaced vector PWM- Harmonic elimination PWM - Performance index for optimality - optimum PWM – Minimum loss PWM.		
Unit - III	**Modulation of Single Phase VSI**	**9**
Topology of a Single Phase Inverter -Three level Modulation of a Single Phase Inverter-Analytic Calculation of Harmonic Losses-Sideband Modulation-Switched Pulse Position-Switched Pulse Sequence.		
Unit - IV	**Modulation of Three Phase VSI**	**9**
Topology of a Three Phase VSI-Three Phase Modulation with Sinusoidal References- Third Harmonic Reference Injection-Analytic Calculation of Harmonic Losses-Discontinuous Modulation Strategies- Triplen Carrier Ratios and Sub harmonics.		
Unit - V	**Space Vector Modulation**	**9**
Multilevel converter alternatives - Harmonic Elimination applied to multilevel inverters- Minimum Harmonic distortion. Space Vector Modulation - Phase Leg References - Naturally Sampled SVM-Analytical Solution for SVM Harmonic Losses for SVM-Placement of the Zero Space Vector		

Lecture: 45, Total: 45

REFERENCES:

1.	D. Grahame Holmes and Thomas A. Lipo, “Pulse Width Modulation for Power Converters: Principles and Practice”, IEEE Press Series on Power Engineering, Wiley, 2003.
2.	Mohammed H. Rashid, “Power Electronics: Circuits, Devices and Applications”, 4th Edition, Eastern Economy Edition, USA , 2004.
3.	Dorin O. Neacsu, “Power-Switching Converters: Medium and High Power”, 2nd Edition, CRC Press, United States,2006.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	explain the fundamental concepts of pulse width modulation techniques	Understanding (K2)
CO2	list the types of pulse width modulation techniques based on its performance index	Applying (K3)
CO3	make use of inverter topologies in applying PWM techniques	Understanding (K2)
CO4	explain the strategies involved for harmonic elimination using PWM	Understanding (K2)
CO5	summarize the space vector modulation techniques and its advantages	Understanding (K2)

Mapping of COs with POs and PSOs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	2	1	3
CO2	3	1	3
CO3	2	1	3
CO4	2	1	3
CO5	2	1	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	60	10				100
CAT2	30	70					100
CAT3	30	70					100
ESE	30	60	10				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20PEE14 – COMPUTER AIDED SIMULATION AND DESIGN OF POWER ELECTRONIC SYSTEMS

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	3	PE	3	0	0	3

Preamble	The ultimate intention of this subject is to model/simulate various types of power semiconductors, power electronics converters for their role in monitoring, controlling and conversion.	
Unit - I	**Introduction**	**9**
Review of power electronic software simulation tools, PSPICE, PSIM- Importance of simulation – Challenges in simulation - **PSpice** : File formats - Description of circuit elements - Circuit description – Output variables - Dot commands. **PSIM** : elements of psim - power circuit and control circuit component – circuit schematic design using simcad - simcoupler – Magnet plugins – waveform process using simview. **MATLAB and Simulink :** Toolboxes of MATLAB - Programming and file processing in MATLAB – Model definition and model analysis using SIMULINK - S-Functions - Converting S Functions to blocks.		
Unit - II	**Modeling and Simulation of Power Electronic Devices**	**9**
Model,Statement,Characteristics and Parameters of Diode , BJT,MOSFET,IGBT and GTO using PSpice , PSIM and MATLAB.		
Unit - III	**Simulation of AC/DC Converters**	**9**
Diode rectifiers -Controlled rectifiers- Single-Phase Half-Wave Controlled Rectifier -Single-Phase Full-Wave Controlled Rectifier-Three-Phase Full-Wave Controlled Rectifier Simulation Using PSPICE, PSIM and Simscape MATLAB Analysis		
Unit - IV	**Simulation of DC/DC Converters**	**9**
DC Switch – BJT and MOSFET based Choppers buck and boost Using PSPICE, PSIM and Simscape MATLAB Analysis		
Unit - V	**Simulation of DC/AC Converters**	**9**
Pulse-Width-Modulated Inverters - Single-Phase Half-Bridge and Full-Bridge Inverter-Single-Phase Full-Bridge Inverter with PWM and SPWM -Three-Phase Bridge Inverter using Electrical Circuit Simulation Using PSPICE, PSIM and Simscape MATLAB Analysis		

Lecture: 45, Total: 45

REFERENCES:

1.	Muhammad H. Rashid, “SPICE for Power Electronics and Electric Power”, 3rd Edition, Taylor & Francis, 2005.
2.	M. Godoy Simoes, Felix A. Farret, “Modeling Power Electronics and Interfacing Energy Conversion Systems”, IEEE press, Wiley publications,2017 .
3.	Partha S. Mallick, “MATLAB and SIMULINK: Introduction to Applications”, 4th Edition,Scitech Publications (India), 2011.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	choose suitable software package for power electronic circuits analysis	Understanding (K2)
CO2	understand the principle of controlled devices and model various semiconductor devices in Pspice environment	Understanding (K2)
CO3	Apply the simulation model for Rectifier in SIMULINK and PSIM environment	Applying (K3)
CO4	Apply the simulation model for chopper in SIMULINK and PSIM environment	Applying (K3)
CO5	Apply the simulation model for inverter in SIMULINK and PSIM environment	Applying (K3)

Mapping of COs with POs and PSOs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	3	1	3
CO2	3	1	2
CO3	3	1	3
CO4	3	1	3
CO5	3	1	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	40	30				100
CAT2	30	40	30				100
CAT3	30	40	30				100
ESE	30	40	30				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20PEE15 – ENERGY CONSERVATION, MANAGEMENT AND AUDITING

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	3	PE	3	0	0	3

Preamble	The aim of the course is to understand the basics of energy conservation techniques, energy auditing in industries and the associated economical benefits.	
Unit - I	**Energy**	**9**
Energy Scenario – India and World – Energy Resources Availability in India– Energy consumption – Pattern, Energy and Environment - Energy Security - Energy Conservation and its importance, Energy Conservation Act, 2001 and its features, Smart cities- Smart Transportation- Smart Grid – Internet of Things – Industry 4.0.		
Unit - II	**Energy Audit**	**9**
Energy Audit – Need, Principle, Types, Methodologies, Energy audit approach, Barriers, Role of Energy Manager and Auditor – Energy Audit Questionnaire – Bench marking and Energy Performance – Energy Audit Instruments - Case study.		
Unit - III	**Energy Management**	**9**
Importance of Energy Management, Financial analysis Techniques – Simple Payback Period, Return on Investment, Net present Value, Internal Rate of Return, Cash flows, Risk and Sensitivity Analysis, Financing Options, Energy Performance Contract and Role of ESCOS.		
Unit - IV	**Energy Conservation in Thermal Systems**	**9**
Boilers –Boiler Types and classification – Performance Evaluation of Boilers- Losses in Boilers, Energy Conservation opportunities in Boilers. Energy Conservation in Thermal Systems – Needs and Advantages. – Properties of steam – Assessment of steam distribution losses, steam leakages, steam trapping, Various Energy Conservation measures in Steam Systems.		
Unit - V	**Energy Efficient technologies in Electrical and Lighting System**	**9**
Maximum Demand Controllers, Automatic Power Factor Controllers, Energy Efficient motors, Soft starters with Energy Saver, Variable speed drives, Energy Efficient transformers, Electronic Ballast, Energy Efficient Lighting Controls- Occupancy Sensors, Time based control.		

Lecture: 45, Total: 45

REFERENCES:

1. "Book I - General Aspect of Energy Management and Energy Audit", 3rd Edition, Bureau of Energy Efficiency, Ministry of Power, India, 2010.
2. "Book II - Energy Efficiency in Thermal Utilities", 3rd Edition, Bureau of Energy Efficiency, Ministry of Power, India, 2010.
3. "Book III - Energy Efficiency in Electrical Utilities", 3rd Edition, Bureau of Energy Efficiency, Ministry of Power, India, 2010.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	outline the energy scenario	Understanding (K2)
CO2	explain the principles and methodologies of Energy audit	Understanding (K2)
CO3	apply various financial techniques for economic analysis	Applying (K3)
CO4	apply the energy performance measures in Thermal System	Applying (K3)
CO5	apply the energy performance measures in Electrical System	Applying (K3)

Mapping of COs with POs and PSOs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	2	1	2
CO2	2	1	2
CO3	3	2	2
CO4	3	2	2
CO5	3	2	2
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	70					100
CAT2	30	50	20				100
CAT3	30	40	30				100
ESE	30	50	20				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20PEE16 – VECTOR CONTROL OF AC MACHINES

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	3	PE	3	0	0	3

Preamble	Objective of the course is to understand the space vector model of alternating current machines. Derive and analyze the vector control techniques for induction, synchronous and permanent magnet synchronous motor using computer digital simulation.	
Unit - I	**Space Vector Model**	**9**
Applications of Speed and Torque Control – Sinusoidal Distribution of Stator Winding – Stator Inductances: Magnetizing, Mutual and Leakage – Rotor Inductances – Mutual Inductance between Stator and Rotor – Space Vector – Stator and Rotor Flux Linkages – Stator and Rotor Voltage Equation in Terms of Space Vector.		
Unit - II	**Dynamics Analysis of Induction Machines**	**9**
dq Winding Representation: Stator, Rotor and Mutual Effect between Stator and Rotor – Mathematical Relationship – Flux Linkages of dq Winding – dq Winding Voltage Equation – Electromagnetic Torque – Electrodynamics – Computer Simulation.		
Unit - III	**Vector Control of Induction Machines**	**9**
Emulation of DC and BLDC Performance – Vector Control of Induction Motor Drive: Qualitative Examination – Analogy to Current Excited Transformer – dq axis Winding Representation – Vector Control with d-Axis Aligned with Rotor Flux – Mathematical Description and Modeling of Vector Control.		
Unit - IV	**Vector Control of Synchronous Machine**	**9**
Magnetizing Flux Oriented Control –Variable Frequency Operation of Salient Pole Synchronous Machine – Rotor Oriented Control of Reluctance Machines – Considerations of the Effects of Main Flux Saturation		
Unit - V	**Vector Control of PM Synchronous Machine**	**9**
PMSM with Surface Mounted Magnets – Control Scheme for of Rotor Oriented Controlled PMSM with Interior Magnets – Stator Flux Oriented Control – Rotor Oriented Control		

Lecture: 45, Total: 45

REFERENCES:

1.	Ned Mohan, “Advanced Electric Drives”, 1st Edition, John Wiley & Sons Publishers, New Delhi, 2014.
2.	Peter Vas, “Vector control of AC machines”, 3rd Edition, Oxford University Press, New York, 1990.
3.	Bimal. K. Bose, “Modern Power Electronics and AC Drives ”, 1st Edition, Prentice Hall PTR, New Delhi ,2001
4.	R. Krishnan, “Electric Motor Drives: Modeling, Analysis and Control ”, 1st Edition, Pearson Education India, New Delhi, 2015

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	understand the fundamentals of space vector model	Understanding (K2)
CO2	analyze the dynamic model of induction machine using computer simulation	Applying (K3)
CO3	derive and analyze the vector control methods for induction machine	Applying (K3)
CO4	derive and analyze the vector control methods for synchronous machine	Applying (K3)
CO5	derive and analyze the vector control methods for PM synchronous machine	Applying (K3)

Mapping of COs with POs and PSOs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	2	1	
CO2	3	2	1
CO3	3	2	1
CO4	3	2	1
CO5	3	2	1
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	50	30				100
CAT2	20	50	30				100
CAT3	20	50	30				100
ESE	20	50	30				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20PEE17 – ELECTROMAGNETIC FIELD COMPUTATION AND MODELLING

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	4	PE	3	0	0	3

Preamble	This course will provide foundation in formulation and computation of Electromagnetic Fields using analytical and numerical methods. To impart knowledge in fundamentals of FEM and to compute and analyze the field quantities using FEM	
Unit - I	**Introduction**	**9**
Review of basic field theory – Maxwell's equations – Constitutive relationships and Continuity equations – Laplace, Poisson and Helmholtz equation – principle of energy conversion – force/torque calculation		
Unit - II	**Basic Solution Methods for Field Equations**	**9**
Limitations of the conventional design procedure, need for the field analysis based design, problem definition, boundary conditions, solution by analytical methods-direct integration method – variable separable method – method of images, solution by numerical methods- Finite Difference Method		
Unit - III	**Formulation of Finite Element Method (FEM)**	**9**
Variational Formulation – Energy minimization – Discretisation – Shape functions –Stiffness matrix –1D and 2D planar and axial symmetry problems		
Unit - IV	**Computation of Basic Quantities Using FEM Packages**	**9**
Basic quantities – Energy stored in Electric Field – Capacitance – Magnetic Field – Linked Flux – Inductance – Force – Torque – Skin effect – Resistance		
Unit - V	**Design Applications**	**9**
Design of Insulators –Magnetic actuators – Current and Potential transformers – Rotating machines.		

Lecture: 45, Total: 45

REFERENCES:

1.	Matthew. N.O. Sadiku, S.V. Kulkarni, "Elements of Electromagnetics", 6th Edition, Oxford University Press, Asian Edition 2015.
2.	Nicola Biyanchi, "Electrical Machine analysis using Finite Elements", Taylor and Francis Group, CRC Publishers, 2005
3.	Kraus,D.A Fleisch "Electromagnetics With Applications" 5th edition, Tata Mcgraw Hill Publication- 2010

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	understand the fundamentals of electromagnetic wave equations	understanding (K2)
CO2	analyse the concepts fields by different methods	applying (K3)
CO3	gain basic knowledge in finite element method	Applying (K3)
CO4	apply knowledge to find the energy stored in different medium	Applying (K3)
CO5	design some electrical components using FEM technique	Applying (K3)

Mapping of COs with POs and PSOs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	2	1	
CO2	3		1
CO3	3	2	
CO4	3	1	1
CO5	3	2	1
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	40	60					
CAT2	30	30	40				
CAT3	30	30	40				
ESE	30	30	40				

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20PEE18 – INTELLIGENT CONTROLLERS

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	20PET12, 20PET13	4	PE	3	0	0	3

Preamble	The objective of the course is to investigate the main principles of modern power electronic control strategies using artificial networks and fuzzy logic with aid of practical examples intended for research and product development.	
Unit - I	**Artificial Neural Networks**	**9**
Introduction – Biological Neural Networks – Applications – Typical Architectures – Setting the weights – Activation Functions – Mc Culloch Pitt Neuron – HebbNet- Case study: ANN for inverter control.		
Unit - II	**Learning Methods**	**9**
Perceptron – Adaline – Madaline – Kohonen Self Organizing Maps – Learning Vector Quantization – Standard Back propagation - Case study: ANN for chopper control.		
Unit - III	**Fuzzy Logic**	**9**
Classical Sets and Fuzzy Sets: Operations and Properties – Classical Relations and Fuzzy Relations: Cardinality, Operations and Properties – Features of Membership Function – Fuzzification – Defuzzification to scalars - Case study: FLC for inverter control.		
Unit - IV	**Fuzzy Systems**	**9**
Rule Based Systems – Aggregation of Fuzzy Rules – Graphical Techniques of Inference: Mamdani Fuzzy Models –Sugeno Fuzzy Models –Tsukamoto Fuzzy Models - Case study: FLC for chopper control.		
Unit - V	**Control Applications**	**9**
Applications of Neural Networks and Fuzzy Logic: Maximum Power Point Tracking - Speed Control for Electrical Machines - Harmonic Elimination in Power Converters.		

Lecture: 45, Total: 45

REFERENCES:

1. Laurene Fausett, “Fundamentals of Neural Networks: Architectures, Algorithms and Applications”, 15th Impression, Pearson, 2013.
2. Timothy J. Ross, “Fuzzy Logic with Engineering Applications”, 3rd Edition, Wiley, united Kingdom, 2011.
3. Jang J.S.R., Sun C.T., and Mizutani E., “Neuro-Fuzzy and Soft Computing”, 2nd Edition,Pearson Education, 2004.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	interpret and analyze the importance of artificial neural networks	Understanding (K2)
CO2	examine the concepts of neural network learning methods	Applying (K3)
CO3	gain fundamental knowledge on fuzzy logic and its implementation procedures	Understanding (K2)
CO4	illustrate the fuzzy principles through rules and inference mapping	Understanding (K2)
CO5	develop intelligent control techniques for real time applications	Applying (K3)

Mapping of COs with POs and PSOs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	3	1	1
CO2	3	2	1
CO3	3	1	1
CO4	3	2	1
CO5	3	3	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	70					100
CAT2	30	50	20				100
CAT3	30	70					100
ESE	30	50	20				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20PEE19 – SYSTEM THEORY

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	4	PE	3	0	0	3

Preamble	The aim of the subject is to give an adequate exposure to Z-Plane, State Space, Stability analysis and State Feedback Control	
Unit - I	**Introduction to Digital Control System**	**9**
Elements of Digital control system - Classifications of discrete time signals - Time domain models for discrete time systems. Sampling and reconstruction of signals - Frequency domain representation of sampling theorem - Nyquist rate, Aliasing. Mathematical model of sample and hold circuits-Practical aspects of choice of sampling rate.		
Unit - II	**Z-Plane Analysis of Discrete-Time Control Systems**	**9**
Review of Z transform - Relationship between s plane and z plane - Difference equation representation of discrete time system - Pulse transfer function - Modified Z transform - Digital PID controllers - Zeigler - Nichols tuning method.		
Unit - III	**State Space Analysis and its Solution**	**9**
Review of state space representation - Conversion of continuous state model to discrete state model - State diagram - Solution of discrete time state model: autonomous, non-autonomous systems - State transition matrix - Controllability and Observability.		
Unit - IV	**State Feedback Control**	**9**
Design of state feedback controller - Design of reduced and full order observers - Steady state error in state space - PI feedback - Digital compensator design - Digital filter properties - Kalman"s filter.		
Unit - V	**Lyapunov Stability Analysis**	**9**
Introduction-Equilibrium Points- BIBO Stability-Stability of LTI Systems- Stability in the sense of Lyapunov – 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 – Krasovskil's and Variable-Gradiant Method.		

Lecture: 45, Total: 45

REFERENCES:

1. Gopal M., "Digital Control and State Variable Methods", 4th Edition, Tata McGraw Hill, New Delhi, 2012.
2. Kuo B.C., "Digital Control Systems", 2nd Edition, Oxford University Press, New delhi, 2012.
3. Ogata K., "Discrete Time Control Systems", 2nd Edition, Prentice Hall, New Jersey, 2011.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	explain the basic concepts in digital control system	Understanding(K2)
CO2	analyze the Discrete time control System by using Z-plane	Applying (K3)
CO3	develop the mathematical model of linear discrete-time control systems using transfer functions and state-space models	Understanding (K2)
CO4	analyze transient and steady-state behaviors of linear discrete-time control systems	Applying (K3)
CO5	design controllers for linear discrete-time control systems using Lyapunov stability method	Applying (K3)

Mapping of COs with POs and PSOs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	3		2
CO2	2		3
CO3	2		2
CO4	2		3
CO5	2	2	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	50	20				100
CAT2	20	40	40				100
CAT3	20	40	40				100
ESE	20	40	40				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20PEE20 – BIOMEDICAL INSTRUMENTATION

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	4	PE	3	0	0	3

Preamble	This course is aimed to make the students acquire an adequate knowledge of physiological systems with parameters that are clinically important and fundamental principles of equipment that are actually in use at the present day	
Unit - I	**Human Physiology and Transducer Principles**	**9**
Cell and its structure **-** Resting and action potentials **–** Different systems of human body - Skeletal system - Circulatory system - Respiratory system - Excretory system-Central nervous system - Peripheral nervous system Classification of transducers - active and passive transducers - Piezoelectric transducer - Strain gauges - Photoelectric type resistive transducers - Capacitive transducer- Inductive transducer - Thermistors - Ultrasonic transducer		
Unit - II	**Biomedical Recording and patient safety**	**9**
Components of the Bio medical instrument system- Electrodes: Micro electrode-depth and needle electrode-surface electrodes. Amplifiers: Medical preamplifiers-Chopper amplifiers-Isolation amplifier. ECG-EEG-EMG-EOG: Lead systems, recording methods and typical waveforms. Patient safety: Electrical shock hazards-leakage currents		
Unit - III	**Non Electrical Parameters Measurement and Diagnostic Procedures**	**9**
Patient monitoring systems: Measurement of heart rate-Blood pressure Measurement- Cardiac output measurement. Pulmonary function analysers: Pulmonary function measurements - Spirometry. Blood gas analyzers: Blood pH measurement-Measurement of blood pCO2-Blood pO2 measurement. Oximeters: Pulse oximeter.		
Unit - IV	**Modern Medical Imaging Systems**	**9**
Radiography and fluoroscopy-X-ray machine - Computer tomography-Thermography-Ultrasonic imaging systems-Magnetic resonance imaging–Positron emission tomography–Single photon emission computed tomography.		
Unit - V	**Applications of Bio Medical Devices**	**9**
Physiological assist devices: Pacemakers: Ventricular asynchronous pacemaker-Ventricular synchronous pacemaker. Defibrillators: A.C.Debrillator- D.C.Defibrillator - Synchronised d.c defibrillator. Heart lung machine - Kidney machine. **Operation Theatre Equipment:** Surgical diathermy-Short wave diathermy- Ventilators -Lithotriptors: The stone disease problem-First lithotriptor machine		

Lecture: 45, Total: 45

REFERENCES:

1. Arumugam M, “Bio-Medical Instrumentation”, 2nd Edition, Anuradha Publications, Kumbakonam,2014
2. Khandpur R.S, “Handbook of Biomedical Instrumentation”, 2nd Edition, Tata McGraw-Hill, New Delhi,2012
3. Pandey O N, “Fundamentals of Biomedical Instrumentation”, 4th Edition, S.K.Kataria & Sons, New Delhi,2013

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	understand and analyze biomedical instrumentation systems and their applications to various industries	Analyzing(K4)
CO2	analyze the acquisition concepts in the bio potential recorders	Analyzing(K4)
CO3	Recognize various electrical parameters of the human system	Understanding(K2)
CO4	understand various imaging modalities in hospitals	Understanding(K2)
CO5	apply the familiarized therapeutic concepts in the recent trends of biomedical devices	Applying(K3)

Mapping of COs with POs and PSOs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	3		1
CO2	3		1
CO3	3		1
CO4	3		1
CO5	3		1
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	50	10	10			100
CAT2	30	50	10	10			100
CAT3	30	60	10				100
ESE	30	50	10	10			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20PEE21 – MICROCONTROLLER BASED SYSTEM DESIGN

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	4	PE	3	0	0	3

Preamble	To impart knowledge on Microcontroller based system design and to provide case study experiences for microcontroller based applications in power electronics.	
Unit - I	**8051 Microcontroller**	**9**
Architecture – memory organization – addressing modes – instruction set– Timer/ Counter – Assembly Language Programming – Serial Communication Programming, Interrupt Programming – RTOS for 8051 – RTOS Lite – Full RTOS – Task creation and run – LCD digital clock/thermometer using Full RTOS		
Unit - II	**Embedded System**	**9**
Introduction to embedded systems – hardware and software components –types – examples –system on chip-challenges in embedded computing system design – embedded system design process. Serial and parallel communication devices-Watch dog timer – Serial communication using I2C- CAN USB buses –Parallel Communication using ISA- PCIPCI/X buses.		
Unit - III	**PIC Microcontrollers**	**9**
History and features –Architecture – memory organization – addressing modes – instruction set – PIC progrmming –I/O port, Data Conversion. Interfacing PIC to LCD – Keyboard, Stepper motor interfacing.		
Unit - IV	**ARM Processor**	**9**
ARM Architecture – Instruction Set – Instruction Execution – Implementation – ARM programmer's model –ARM Assembly Language Programming–Simple Examples–Architectural Support for Operating systems–ARM coprocessor interface – Embedded ARM Applications.		
Unit - V	**System Design-Case Study**	**9**
Firng pulse generation for typical single phase and Three Phase converters and inverters - PWM Techniques – PID control of DC motor – Control of AC/DC electric drives – Solar Power Conditioning (MPPT).		

Lecture: 45, Total: 45

REFERENCES:

1. Muhammad Ali Mazidi, Rolin D. Mckinlay, Danny Causey 'PIC Microcontroller and Embedded Systems using Assembly and C for PIC18', 2nd edition Pearson Education 2016.
2. Kenneth Ayala, "The 8051 Microcontroller and its Programming", 3rd edition,Thomson-Delmar Learning, 2005.
3. Furber,S., "ARM System on Chip Architecture" Addison Wesley trade Computer Publication, 2nd edition 2009.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	Outline the basic concepts of 8051 microcontroller/RTOS and develop the ASP for various applications.	Applying (K3)
CO2	Summarize embedded system and its series/parallel communication.	Understanding (K2)
CO3	Explain the architectural features of PIC microcontroller and its interfacing.	Understanding (K2)
CO4	Discuss and develop ASP for various applications of ARM processor.	Applying (K3)
CO5	Select an appropriate processor for particular power electronics applications and also design.	Understanding (K4)

Mapping of COs with POs and PSOs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	3	1	2
CO2	3		1
CO3	3		1
CO4	3	1	2
CO5	2	1	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	50	30				
CAT2	20	70	10				
CAT3	20	20	30	30			
ESE	10	35	35	20			

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20PEE22 – ELECTRICAL SAFETY ENGINEERING

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	4	PE	3	0	0	3

Preamble	To enable the students to acquire the knowledge of safety rules and regulations, and demonstrate the awareness of hazards in the workplace. To familiarize the students with the safety of equipments.	
Unit - I	**Introduction to Electrical Safety**	**9**
Basic Definitions and Nomenclature - Fundamentals of Electrical Safety - Mathematical Principles of Electrical Safety - The Earth - Effects of Electric Currents Passing Through the Human Body and Safety Requirements.		
Unit - II	**Study of Electrical Safety Components**	**9**
Introduction to conductors and insulators - Wire Characteristics– Ampacity - Insulation Type, Wire Size, Cables & Cords – Electrical Standards- Safety against over voltages - Safety against Static Electricity.		
Unit - III	**Indoor and Outdoor Safety Precautions**	**9**
Indoor safety-Check Equipment - Wet/Damp Areas, Metal Objects - Electrical Emergencies. Outdoor safety-Overhead Power Lines, Underground Power Lines, Outdoor Equipment, Antennas/Ladders, Recreational Safety, Job Site Hazards, Electrical Emergencies.		
Unit - IV	**Electrical Hazards**	**9**
Main Factors in Electrical Accidents-Electrical Shock- Definition- Arc Flash-Arc Flash Burn Injuries -Arc Blast Pressure - Inhalation Injuries- Determining Safe Approach Distance Determining Arc Hazard Category.		
Unit - V	**Safety Methods of Equipments**	**9**
The Six Step Safety Methods- Pre Job Briefings- Hot -Work Decision Tree-Safe Switching of Power System- Lockout-Tag Out-Flash Hazard Calculation and Approach Distances- Calculating the Required Level of Arc Protection-Safety Equipment - The One Minute Safety Audit.		

Lecture: 45, Total: 45

REFERENCES:

1.	John Cadick, " Electrical Safety Handbook", 4th Edition, Tata Mc Graw-Hill Education, New York, USA, 2012
2.	Fortham Cooper W , Electrical Safety Engineering", 1st Edition, Butterworth and Company, London,1986
3.	Dennis Neitzel, Al Winfield, "Electrical Safety Handbook", 4th Edition, Tata Mc Graw-Hill Education, New York,2012

	COURSE OUTCOMES: On completion of the course, the students will be able to	**BT Mapped (Highest Level)**
CO1	develop basic knowledge on safety	Understanding (K2)
CO2	Describe the electrical safety equipment	Understanding (K2)
CO3	Select appropriate safety precautions for indoor and outdoor equipment	Understanding (K2)
CO4	Expand skills in identifying the presence of electrical hazards to minimize risks	Understanding (K2)
CO5	Apply various safety procedures of electrical equipment	Applying (K3)

Mapping of COs with POs and PSOs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	2	1	
CO2	2	1	
CO3	2	1	
CO4	2	1	
CO5	3	2	1
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	70					100
CAT2	30	70					100
CAT3	30	50	20				100
ESE	30	50	20				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20PEE23 – PROJECT MANAGEMENT

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	4	PE	3	0	0	3

Preamble		
Unit - I	**Philosophy and Concepts**	**9**
Need – Goals- Evolution-Different Forms -Project Management in Manufacturing, Service and Government Sectors; Systems Development Cycle – Conception phase: proposal, contracting – Definition phase – Execution phase: production / build, implementation – Operation phase- System Development in Industries, service and government sectors - case study.		
Unit - II	**Planning Fundamentals**	**9**
Planning Steps – Project master plan - Tools for project planning – work break down structure, responsibility matrix, events and mile stones- Gantt charts. Network Scheduling – the critical path – early and late times – slack –float – calendar scheduling.		
Unit - III	**PERT**	**9**
Time estimates – probability of finishing by target completion date – criticisms of PERT - CPM – Time cost relationship – reducing project duration – shortest duration – total project cost; Scheduling with Resource Constraints – resource loading and leveling – constrained resources; Introduction to GERT network - case studies in PERT/CPM.		
Unit - IV	**Project Cost Estimation**	**9**
Process – classification-expert opinion, analogy estimate, parametric estimate, cost engineering, Contingency amount - Elements of budgets and Estimates – direct labour, direct non- labour, overhead, general and administrative expenses, profit and total billing. Project cost accounting – budgeting using cost accounts - cost summaries, cost schedules and forecasts – case study. Project Management Information Systems (PMIS): Functions – Computer based PMI Systems – Web-Based project management		
Unit - V	**Project Control**	**9**
Cost accounting systems- project control process - Project control emphasis- Performance Analysis – cost, schedule, work package analysis, performance indices, updating time estimates, technical performance measurement- Performance Index monitoring – variance limits, controlling changes, contract administration, control problems, case study. Project Evaluation: Review meetings, reporting, terminating, termination responsibilities, closing the contract, project extensions, project summary evaluation.		

Lecture: 45, Total: 45

REFERENCES:

1.	Nicholas John M., “Project Management for Business and Technology”, Prentice Hall India, New Delhi, 2011.
2.	Pagnoni Anastasia, “Project Engineering: Computer Oriented Planning and Operational Decision Making”, Springer-Verlag, Berlin, 2012.
3.	Pannerselvam R., “Project Management”, PHI Learning Pvt. Ltd., 2010.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	understanding of a schematic carrying out a project indicating various phases	Understanding (K2)
CO2	apply project management techniques for executing projects	Applying (K3)
CO3	understand various control measures in project implementation	Understanding (K2)
CO4	analysis the techniques and procedures for defining, scheduling and budgeting project activities to achieve project quality, time, and cost goals.	Evaluating (K5)
CO5	monitor, evaluate, control and executing the project.	Evaluating (K5)

Mapping of COs with POs and PSOs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	3	1	2
CO2	3	1	2
CO3	3	2	2
CO4	3	2	2
CO5	3	2	2
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	40	40				100
CAT2	20	40	40				100
CAT3	20	20	20	20	20		100
ESE	20	20	20	20	20		100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20PEE24 – HVDC and FACTS

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	4	PE	3	0	0	3

Preamble	This course brings the applications of power electronic applications in power system by incorporating the features of various compensators. In addition, it also provides an insight to harmonics and filters in improving the performance parameters of power system.

Unit - I	**HVDC Transmission**	**9**
Introduction – Comparison of AC and DC transmission- Application of DC transmission-Description of DC transmission system-Planning for DC transmission- Modem trend in DC transmission-Characteristics of twelve pulse converters- Principle of DC link control - Converter control characteristics – System control hierarchy-Firing angle control-CEA control.		
Unit - II	**MTDC Systems and Filtering Approach**	**9**
Introduction to MTDC –Potential applications of MTDC systems-Types of MTDC systems-control and protection of MTDC systems- Smoothening reactor-Transient over voltages in DC line - DC breakers- Monopolar operation - Effects of proximity of DC and AC transmission systems.		
Unit - III	**Static Shunt Compensators**	**9**
Objectives of Shunt Compensation - Methods of Controllable VAR generation - Static VAR Compensators: SVC and STATCOM - Comparison between SVC and STATCOM. **Static Series Compensator:** Objectives of Series Compensation-Variable Impedance Type Series Compensators: GCSC, TSSC, TCSC - Switching Converter Type Series Compensators: SSSC -External Control of Series Reactive Compensators- Characteristics and Features of Series Compensators.		
Unit - IV	**Static Voltage and Phase Angle Regulators**	**9**
Objectives of Voltage and Phase Angle Regulators –Functional Requirements – Thyristor Controlled Voltage and Phase Angle Regulators (TCVRs and TCPARs) – Switching Converter based Voltage and Phase Angle Regulators- Hybrid Phase Angle Regulators. **Combined Compensators:** Introduction – Unified Power Flow Controller (UPFC) – Operating Principle-Conventional control capabilities-Real and reactive Power Flow Control – Interline Power Flow Controller (IPFC)- Principles and Characteristics – Control Structure- Generalized and Multifunctional FACTS Controllers.		
Unit - V	**Harmonics and Filters**	**9**
Harmonics creating loads – Modelling - Harmonic propagation - Series and parallel resonances - Harmonic power flow - Mitigation of harmonics – Filters - Passive filters - Active filters - Shunt, Series hybrid filters - Voltage sags & swells - Voltage flicker - Mitigation of power quality problems using power electronic conditioners - IEEE standards.		

Lecture: 45, Total: 45

REFERENCES:

1.	Narain G. Hingorani and Laszlo Gyugyi, “Understanding FACTS Concepts and Technology of Flexible AC Transmission Systems”, 1st Edition, IEEE Press, United States, 2000.
2.	Padiyar K.R., “HVDC Power Transmission System”, 2nd Edition, New Academic Science Ltd., INDIA, 2012.
3.	E. F. Fuchs & Mohammad A.S. Masoum, “Power Quality in Power Systems and Electrical Machines”, 2nd Edition, Elsevier Academic Press, United States, 2015.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	explain the concepts of HVDC transmission and converter control characteristics	Understanding (K2)
CO2	explain the potential applications of MTDC systems and usage of smoothening reactor	Understanding (K2)
CO3	make use of shunt and series compensators for the performance improvement in power system	Applying (K3)
CO4	explain the principle and operation of combined compensators and voltage, phase angle regulator	Understanding (K2)
CO5	demonstrate the filter design for the suppression of harmonics in the power system	Understanding (K2)

Mapping of COs with POs and PSOs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	2		3
CO2	3		3
CO3	3	2	3
CO4	2		3
CO5	3	2	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	70					100
CAT2	20	70	10				100
CAT3	30	70					100
ESE	30	60	10				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20PEE25 – EMBEDDED SYSTEM AND APPLICATIONS

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	4	PE	3	0	0	3

Preamble	To impart knowledge on embedded based system design and to provide application oriented study on networking and multimedia platform	
Unit - I	**Introduction**	**9**
Embedded system- characteristics of embedded system- categories of embedded system- requirements ofembedded systems- challenges and design issues of embedded system- trends in embedded system- systemintegration- hardware and software partition- applications of embedded system- control system and industrial automationbiomedical-data communication system-network information appliances- IVR systems- GPS systems.		
Unit - II	**PIC controller and programming**	**9**
PIC Microcontroller 16F87X: Architecture – Features – Resets –Memory Organizations: Program Memory, Data Memory – InterruptsPIC Peripherals – I/O Parallel Ports – Timers –Capture/Compare/PWM (CCP) Modules –ADC - Simple programs using Assembly language.		
Unit - III	**ARM Processor and Programming**	**9**
General concepts - ARM7 - Instruction Set Architecture, Levels in architecture, Functional description - processor and memory organization - Introduction to RISC architecture, pipelining, Instruction issue and execution - Instruction formats - Addressing modes - Data alignment and byte ordering – Simple programs using Assembly language Instruction sets.		
Unit - IV	**Embedded Networking**	**9**
Embedded networking – code requirements – Communication requirements – Introduction to CAN open – CANopen standard – Object directory – Electronic Data Sheets & Device – Configuration files – Service Data Objectives– Network management CAN open messages – Device profile encoder		
Unit - V	**Open Multimedia Application Platform**	**9**
Introduction, architecture, instruction set, addressing modes, applications – OMAP5910 –module overview, display specification, LCD controller operation, Lookup palette, color dithering, output FIFO, LCD controller pins, LCD controller registers, interface to LCD panel signal reset values - TI OMAP Applications Processor - OMAP2420 and OMAP1710 – architecture, features, and applications.		

Lecture: 45, Total: 45

REFERENCES:

1.	Arnold berger, “Embedded system design”, 1st Edition, CMP books, 2001.
2.	Muhammad Ali Mazidi, Janice Gillispie Mazidi., " The 8051 Microcontroller and Embedded systems", 2nd Edition, Person Education, 2004.
3.	SteaveFurber, "ARM system - on - chip architecture", 2nd Edition, Addison Wesley, 2000.
4.	GlafP.Feiffer, Andrew Ayre and Christian Keyold “Embedded Networking with CAN and CAN open”, 1st Edition, Embedded System Academy, 2008.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	Outline the concepts of embedded systems and the role of microcontrollers in embedded systems	Understanding (K2)
CO2:	Illustrate the basic architecture and interfacing concepts of PIC16 microcontroller	Understanding (K2)
CO3:	Describe the architecture and functionality of ARM 7 processor	Understanding (K2)
CO4:	Apply the programming skills for embedded networking and network management	Apply (K3)
CO5:	Apply the system design concepts for various multimedia applications	Apply (K3)

Mapping of COs with POs and PSOs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	2	1	3
CO2	3	1	2
CO3	2	1	3
CO4	2	1	3
CO5	3	2	1
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN							
Test/Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total 100%**
CAT 1	30	70					100
CAT 2	30	60	10				100
CAT 3	30	60	10				100
ESE	30	60	10				100
***±3% may be varied, (CAT1, 2, 3 – 50 marks, ESE – 100 marks)**							

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20PEE26 – ENERGY STORAGE SYSTEMS

Programme & Branch	M.E & Power Electronics and Drives	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	4	PE	3	0	0	3

Preamble	This course is aimed to introduce the fundamental concepts and principles of various energy storage systems that aids in various electrical applications.	
Unit - I	**Energy Storage Technologies**	**9**
Introduction - Need of energy storage - Battery - Components of Cells and Batteries – Classification - Operation of a Cell - Theoretical Cell Voltage, Capacity, and Energy - Electrochemical Principles and Reactions: Cell Polarization - Electrical Double-Layer Capacity and Ionic Adsorption - Mass Transport to the Electrode Surface –Factors affecting battery performance – Standards.		
Unit - II	**Primary and Secondary Batteries**	**9**
Battery parameters and specification - Performance, charging and discharging- storage density, energy density, classical & Modern batteries: Zinc-chloride – Nickel Cadmium- Lead Acid - Nickel Hydride, Lithium Battery-Principle and working.		
Unit - III	**Advanced Batteries for EV Applications**	**9**
Ultracapacitors: Features- Basic Principles of Ultracapacitors - Performance of Ultracapacitors – Mathematical model, Fuel cells: Operating Principles – Characteristics - Polarization loss - fuel cells Technologies - Comparison of fuel cells, Hybridization of Energy Storage systems.		
Unit - IV		**9**
APPLICATIONS OF BATTERIES: Storage of Solar – Greenhouse heating – Power plant Application –Batteries in Space – Storage in Electric Supply Networks – Automotive application in Hybrid and Electric Vehicles – Role of Ultra capacitors in EVs.		
Unit - V	**Thermal and Mechanical Energy Storage**	**9**
Thermal Energy Storage – Energy storage in Hydrogen – Energy Storage in Flywheels – Pumped Hydro Storage – Elastic Energy Storage – Applications		

Lecture: 45, Total: 45

REFERENCES:

1. Iqbal Hussain, “Electric and Hybrid Vehicles: Design Fundamentals, Second Edition” , 2nd Edition, CRC Press, Taylor & Francis Group, 2011.
2. Ali Emadi, Mehrdad Ehsani, John M.Miller, “Vehicular Electric Power Systems”, Special Indian Edition, Marcel dekker, Inc 2010.
3. Tetsuya Osaka, Madhav Datta, “Energy Storage Systems in Electronics”, Gordon and Breach Science Publishers, 2000.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	evaluate the various aspects and performance of EV battery technologies.	Understanding (K2)
CO2	conceptualize the principles of Primary & Secondary batteries.	Understanding (K2)
CO3	illustrate the concepts & Principles of ultracapacitors and fuel cells.	Understanding (K2)
CO4	analyze the requirement of secondary batteries in engineering applications.	Applying (K3)
CO5	identify a suitable energy storage technique for the desirable performance	Applying (K3)

Mapping of COs with POs and PSOs			
COs/POs	**PO1**	**PO2**	**PO3**
CO1	2	1	
CO2	2	1	
CO3	2	1	
CO4	3	2	1
CO5	3	2	1
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy			

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	70					100
CAT2	20	80					100
CAT3	10	70	20				100
ESE	20	60	20				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

Innovation and Business Model Development