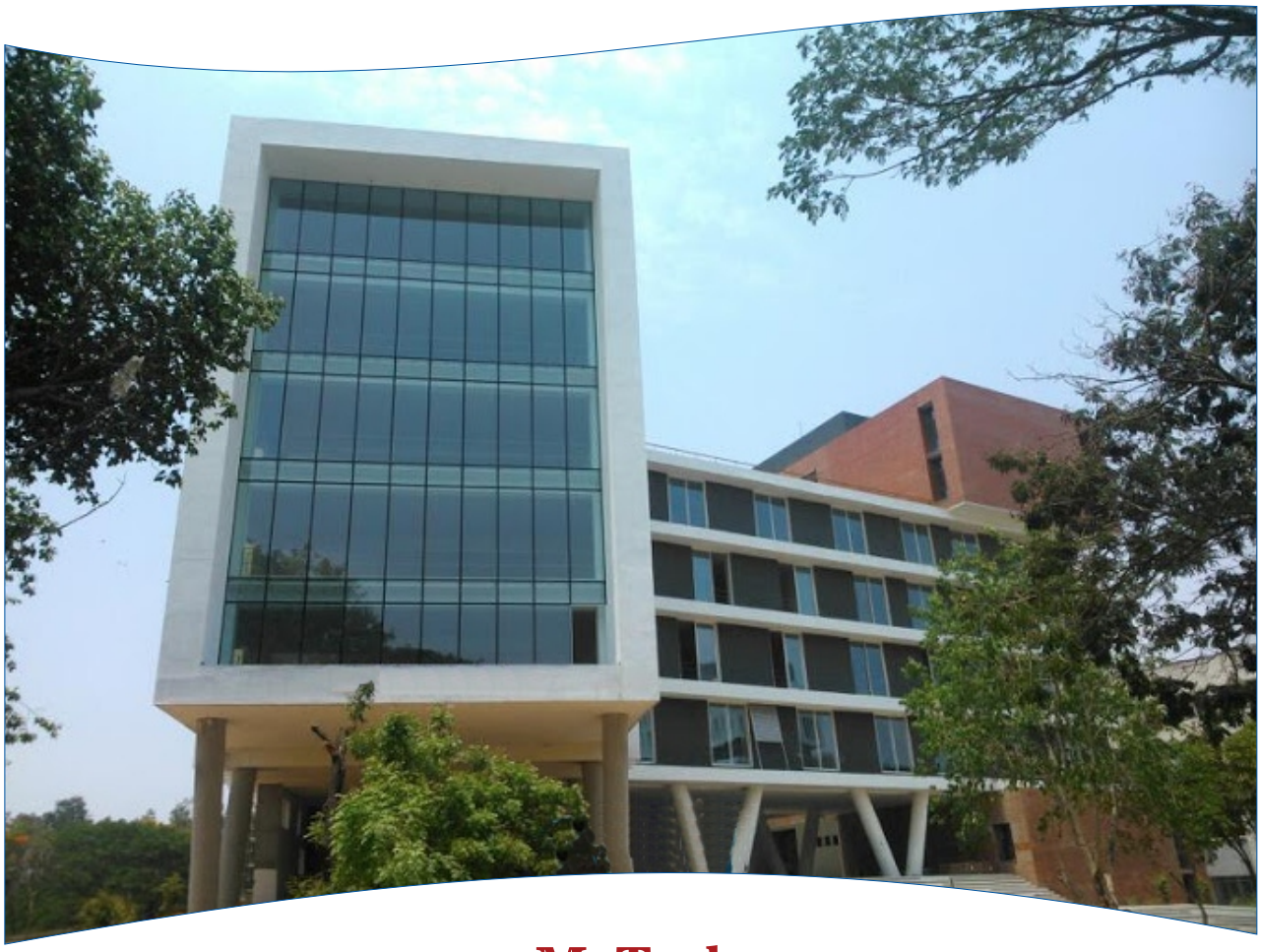
CURRICULUM AND SYLLABI

REGULATIONS - 2016

(As approved by the 9th Academic Council)



M. Tech.

POWER ELECTRONICS AND DRIVES

B.S.ABDUR RAHMAN UNIVERSITY

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

(FORMERLY B.S. ABDUR RAHMAN CRESCENT ENGINEERING COLLEGE)
Rated with A Grade by National Assessment and Accreditation Council
Seethakathi Estate, G.S.T. Road, Vandalur, Chennai - 600 048
www.bsauniv.ac.in

REGULATIONS, CURRICULUM AND SYLLABI

M. Tech.
POWER ELECTRONICS AND DRIVES

(As approved by the 9th Academic Council)

JULY 2016

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UNIVERSITY VISION AND MISSION

VISION

B.S. Abdur Rahman Institute of Science and Technology aspires to be a leader in Education, Training and Research in Engineering, Science, Technology and Management and to play a vital role in the Socio-Economic progress of the Country.

MISSION

- To blossom into an internationally renowned University
- To empower the youth through quality education and to provide professional leadership
- To achieve excellence in all its endeavors to face global challenges
- To provide excellent teaching and research ambience
- To network with global institutions of Excellence, Business, Industry and Research Organizations
- To contribute to the knowledge base through Scientific enquiry, Applied research and Innovation

VISION AND MISSION OF THE DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

VISION

To achieve excellence in the programs offered by the Department of Electrical and Electronics Engineering through quality teaching, holistic learning and innovative research

MISSION

- To offer Under Graduate, Post Graduate & Research programs of industrial and societal relevance
- To provide knowledge and skill in the Design and realization of Electrical and Electronic circuits and systems
- To impart necessary managerial and soft skills to face the industrial challenges
- To pursue academic and collaborative research with industry and research institutions in India and abroad
- To disseminate the outcome of research and projects through publications, seminars and workshops
- To provide conducive ambience for higher education, teaching and research.

PROGRAMME EDUCATIONAL OBJECTIVES AND OUTCOMES

PROGRAMME EDUCATIONAL OBJECTIVES

- To impart education and to train graduate engineers in the field of power electronics which has a significant role in the 21st Century and beyond, in industrial, commercial, residential, aerospace, utility and military applications, with the emphasis on energy saving and solving Environmental pollution problems.
- To engage the graduates in research activities leading to innovative applications of technology like interfacing of power electronic controllers with non-conventional energy sources for it effective utilization, improvising the present systems with the help of Artificial Intelligence techniques, for the benefit of mankind and to become responsible citizens of the country, with a willingness to serve the society.
- To prove scope to work in production, maintenance and research and development division in leading core companies to face the challenges of the future

PROGRAMME OUTCOMES

1. **Engineering knowledge**:
   Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**:
   Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**:
   Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**:
   Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. **Modern tool usage**:
   Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**:
   Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**:
   Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**:
   Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work**:
   Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication**:
    Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance**:
    Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning**:
    Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAMME SPECIFIC OUTCOMES

(i) Be able to formulate and solve complex problems through efficient Power Electronic components.

(ii) Be able to use modern software packages for modeling, design and analysis of Power Electronic components and systems

(iii) Have the capability to work in areas like embedded technology and evolutionary computing and develop power electronic hardware systems for societal needs.

(iv) Have the ability to trouble shoot problems in power electronics and drives

REGULATIONS – 2016
FOR
M. Tech. / MCA / M.Sc. DEGREE PROGRAMMES

1.0 PRELIMINARY DEFINITIONS AND NOMENCLATURE

In these Regulations, unless the context otherwise requires

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

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

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

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

v. **"Academic Council"** means the Academic Council, which is the apex body on all academic matters of this University

vi. **"Dean (Academic Affairs)"** means Dean (Academic Affairs) of B.S. Abdur Rahman University, who administers the academic matters.

vii. **"Dean (P.G. Studies)"** means Dean (P.G. Studies) of B.S. Abdur Rahman University who administers all P.G Programmes of the University in coordination with Dean (Academic Affairs)

viii. **"Dean (Student Affairs)"** means Dean (Student Affairs) of B.S. Abdur Rahman University, who looks after the welfare and discipline of the students.

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

2.0 PROGRAMMES OFFERED, MODE OF STUDY AND ADMISSION REQUIREMENTS

2.1 P.G. Programmes Offered

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

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

2.2 Modes of Study

2.2.1 Full-time

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

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

2.2.3 Part-time

In this mode of study, the students are required to attend classes for the courses in the time slots selected by them, during the daytime (or) evenings (or) weekends.

2.3 Admission Requirements

2.3.1 Students for admission to the first semester of the Master's Degree Programme shall be required to have passed the appropriate degree examination of this University as specified in the Table shown for eligible entry qualifications for admission to P.G. programmes or any other degree examination of any University or authority accepted by this University as equivalent thereto.

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

2.3.3 All part-time students should satisfy other conditions regarding experience, sponsorship etc., which may be prescribed by this Institution from time to time.

2.3.4 Student eligible for admission to M.C.A under lateral entry scheme shall be required to have passed three year degree in B.Sc (Computer Science) / B.C.A / B.Sc (Information Technology)

3.0 DURATION AND STRUCTURE OF THE P.G. PROGRAMME

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

Programme	Min. No. of Semesters	Max. No. of Semesters
M. Tech. (Full Time)	4	8
M. Tech. (Part Time)	6	12
M.C.A. (Full Time)	6	12
M.C.A. (Part Time)	9	18
M.C.A. (Full Time) – (Lateral Entry)	4	8
M.C.A. (Part Time) – (Lateral Entry)	6	12
M.Sc. (Full Time)	4	8
M. Sc. (Part Time)	6	12

3.2 The PG. programmes consist of the following components as prescribed in the respective curriculum

i. Core courses
ii. General Elective courses
iii. Professional Elective courses
iv. Project work / thesis / dissertation
v. Laboratory Courses
vi. Case studies
vii. Seminars
viii. Mini Project
ix. Industrial Internship

3.3 The curriculum and syllabi of all PG. programmes shall be approved by the Academic Council of this University.

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

3.5 Each academic semester shall normally comprise of 80 working days. Semester-end examinations will follow immediately after the last working day.

ELIGIBLE ENTRY QUALIFICATIONS FOR ADMISSION TO P.G. PROGRAMMES

Sl. No.	Name of the Department	P.G. Programmes offered	Qualifications for admission
01	Civil Engineering	M. Tech. (Structural Engineering)	B.E / B. Tech. (Civil Engineering) / (Structural Engineering)
		M. Tech. (Construction Engineering and Project Management)	
02	Mechanical Engineering	M. Tech. (Manufacturing Engineering)	B.E. / B. Tech. (Mechanical / Auto / Manufacturing / Production / Industrial / Mechatronics / Metallurgy / Aerospace /Aeronautical / Material Science / Marine Engineering)
		M. Tech. (CAD/CAM)	
03	Polymer Engineering	M. Tech. (Polymer Technology)	B. E. / B. Tech. Mechanical / Production /Polymer Science or Engg or Tech / Rubber Tech / M.Sc (Polymer Sc./ Chemistry Appl. Chemistry)
04	Electrical and Electronics Engineering	M. Tech. (Power Systems Engg)	B.E / B.Tech (EEE / ECE / E&I / I&C / Electronics / Instrumentation)
		M. Tech. (Power Electronics & Drives)	B.E / B.Tech (EEE / ECE / E&I / I&C / Electronics / Instrumentation)
05	Electronics and Communication Engineering	M. Tech. (Communication Systems)	B.E / B.Tech (EEE/ ECE / E&I / I&C / Electronics / Instrumentation)
		M. Tech. (VLSI and Embedded Systems)	B.E. / B. Tech. (ECE / Electronics / E&I / I&C / EEE)
06	ECE Department jointly with Physics Dept.	M. Tech. (Optoelectronics and Laser Technology)	B.E. / B. Tech. (ECE / EEE / Electronics / EIE / ICE) M.Sc (Physics / Materials Science / Electronics / Photonics)
07	Electronics and Instrumentation Engineering	M. Tech. (Electronics and Instrumentation Engineering)	B.E. / B. Tech. (EIE / ICE / Electronics / ECE / EEE)

Sl. No.	Name of the Department	P.G. Programmes offered	Qualifications for admission
08	Computer Science and Engineering	M. Tech. (Computer Science and Engineering)	B.E. / B. Tech. (CSE / IT / ECE / EEE / EIE / ICE / Electronics / MCA)
		M. Tech. (Software Engineering)	B.E. / B. Tech. (CSE / IT) MCA
		M. Tech. (Network Security)	B.E. / B. Tech. (CSE / IT / ECE / EEE / EIE / ICE / Electronics / MCA)
		M. Tech. (Computer Science and Engineering with specialization in Big Data Analytics)	B.E. / B. Tech. (CSE / IT / ECE / EEE / EIE / ICE / Electronics / MCA)
09	Information Technology	M. Tech. (Information Technology)	B.E / B. Tech. (IT / CSE / ECE / EEE / EIE / ICE / Electronics) MCA
		M. Tech. (Information Security & Digital Forensics)	B.E / B. Tech. (IT / CSE / ECE / EEE / EIE / ICE / Electronics) MCA
10	Computer Applications	M.C.A.	Bachelor Degree in any discipline with Mathematics as one of the subjects (or) Mathematics at +2 level
		M.C.A. – (Lateral Entry)	B.Sc Computer Science / B.Sc Information Technology / B.C.A
		M. Tech. (Systems Engineering and Operations Research)	BE / B. Tech. (Any Branch) or M.Sc., (Maths / Physics / Statistics / CS / IT / SE) or M.C.A.
		M. Tech. (Data & Storage Management	BE / B. Tech. (Any Branch) or M.Sc., (Maths / Physics / Statistics / CS / IT / SE) or M.C.A.
11	Mathematics	M.Sc. (Actuarial Science)	Any Degree with Mathematics / Statistics as one of the subjects of study.
		M.Sc. Mathematics	B.Sc. (Mathematics)
12	Physics	M.Sc.(Physics)	B.Sc.(Physics / Applied Science / Electronics / Electronics Science / Electronics & Instrumentation)
		M.Sc. (Material Science)	B.Sc.(Physics / Applied Science / Electronics / Electronics

Sl. No.	Name of the Department	P.G. Programmes offered	Qualifications for admission
			Science / Electronics & Instrumentation)
13	Chemistry	M.Sc.(Chemistry)	B.Sc (Chemistry / Applied Science)
14	Life Sciences	M.Sc. Molecular Biology & Biochemistry	B.Sc. in any branch of Life Sciences
		M.Sc. Genetics	B.Sc. in any branch of Life Sciences
		M.Sc. Biotechnology	B.Sc. in any branch of Life Sciences
		M.Sc. Microbiology	B.Sc. in any branch of Life Sciences
		M.Sc. Bioscience	B.Sc. in any branch of Life Sciences
		M. Tech. Biotechnology	B. Tech. (Biotechnology / Chemical Engineering) / M.Sc. in any branch of Life Sciences

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

Programme	Minimum prescribed credits
M. Tech.	73
M.C.A.	120
M.Sc.	72

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

- One credit for one lecture period per week (or) 15 periods per semester
- One credit for one tutorial period per week
- One credit each for seminar/practical session/project of two or three periods per week
- One credit for two weeks of industrial internship
- One credit for 15 periods of lecture (can even be spread over a short span of time)

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

P.G. Programme	Full Time		Part Time	
	Non-project Semester	Project semester	Non-project Semester	Project semester
M. Tech.	9 to 28	12 to 28	6 to 12	12 to 28
M.C.A.	9 to 29	12 to 29	6 to 12	12 to 29
M.Sc.	9 to 25	12 to 20	6 to 12	12 to 20

3.9 The student may choose a course prescribed in the curriculum from any department depending on his / her convenient time slot. All attendance will be maintained course-wise only.

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

3.11 A student may be permitted by the Head of the Department to choose electives from other PG programmes either within the Department or from other Departments up to a maximum of nine credits during the period of his/her study, with the approval of the Head of the Departments offering such courses.

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

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

3.14 Industrial internship, if specified in the curriculum shall be of not less than two weeks duration and shall be organized by the Head of the Department.

3.15 Project Work / Thesis / Dissertation

3.15.1 Project work / Thesis / Dissertation shall be carried out under the supervision of a Faculty member in the concerned Department.

3.15.2 A student may however, in certain cases, be permitted to work for the project in an Industrial/Research Organization, on the recommendation of the Head of the Department. In such cases, the project work shall be jointly

supervised by a faculty of the Department and an Engineer / Scientist from the organization and the student shall be instructed to meet the faculty periodically and to attend the review committee meetings for evaluating the progress.

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

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

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

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

4.0 CLASS ADVISOR AND FACULTY ADVISOR

4.1 Class Advisor

A faculty member will be nominated by the HOD as Class Advisor for the whole class.

He / she is responsible for maintaining the academic, curricular and co-curricular records of all students throughout their period of study.

4.2 Faculty Advisor

To help the students in planning their courses of study and for general counseling on the academic programme, the Head of the Department of the students will attach a certain number of students to a faculty member of the department who shall function as Faculty Advisor for the students throughout their period of study. Such Faculty Advisor shall offer advice to the students on academic and personal matters and guide the students in taking up courses for registration and enrolment every semester.

5.0 CLASS COMMITTEE

5.1 Every class of the PG Programme will have a Class Committee constituted by the Head of the Department as follows:

i. Teachers of all courses of the programme

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

Chairperson.

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

iv. Class Advisor / Faculty Advisor of the class - Ex-Officio Member

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

5.2 The Class Committee shall be constituted by the respective Head of the Department of the students.

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

5.4 The Class Committee is required to meet at least thrice in a semester, first within a week of the commencement of the semester, second, after the first assessment and the third, after the semester-end examination to finalize the grades.

6.0 COURSE COMMITTEE

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

7.0 REGISTRATION AND ENROLMENT

7.1 For the first semester every student has to register for the courses within one week from the commencement of the semester

7.2 For the subsequent semesters registration for the courses will be done by the student one week before the last working day of the previous semester. The curriculum gives details of the core and elective courses, project and

seminar to be taken in different semester with the number of credits. The student should consult his/her Faculty Advisor for the choice of courses. The Registration form shall be filled in and signed by the student and the Faculty Advisor.

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

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

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

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

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

7.8 A student undergoing a full time PG Programme should have enrolled for all preceding semesters before registering for a particular semester

7.9 A student undergoing the P.G. programme in Part Time mode can choose not to register for any course in a particular semester with written approval from the head of the department. However the total duration for the completion of the programme shall not exceed the prescribed maximum number of semesters (vide clause 3.1)

8.0 TEMPORARY BREAK OF STUDY FROM THE PROGRAMME

A student may be permitted by the Dean (Academic Affairs) to avail temporary break of study from the programme up to a maximum of two semesters for reasons of ill health or other valid grounds. Such student has to rejoin only in the same semester from where he left. However the total duration for completion of the programme shall not exceed the prescribed maximum number of semesters (vide clause 3.1).

9.0 MINIMUM REQUIREMENTS TO REGISTER FOR PROJECT / THESIS / DISSERTATION

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

Programme	Minimum No. of credits to be earned to enroll for project semester
M. Tech. (Full time / Part time)	18
M.C.A. (Full time / Part time)	45
M.C.A. (Full time / Part time) – (Lateral Entry)	22
M.Sc.(Full time / Part time)	18

9.2 If the student has not earned minimum number of credits specified, he/she has to earn the required credits, at least to the extent of minimum credits specified in clause 9.1 and then register for the project semester.

10.0 DISCIPLINE

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

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

11.0 ATTENDANCE

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

11.2 Ideally every student is expected to attend all classes and earn 100% attendance in the contact periods of every course, subject to a maximum relaxation of 25% for genuine reasons like on medical grounds, representing the University in approved events etc., to become eligible to appear for the semester-end examination in that course, failing which the student shall be awarded "I" grade in that course. If the course is a core course, the student should register for and repeat the course when it is offered next. If the course is an elective, either he/she can register and repeat the same elective or can register for a new elective.

11.3 The students of Full Time mode of study, who have not attended a single hour in all courses in a semester and awarded ‘I’ grade are not permitted to

write the examination and also not permitted move to next higher semester. Such students should repeat all the courses of the semester in the next Academic year.

12.0 SUMMER TERM COURSES

12.1 Summer term courses may be offered by a department on the recommendation of the Departmental Consultative Committee and approved by the Dean (Academic Affairs). No student should register for more than three courses during a summer term.

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

12.3 The number of contact hours and the assessment procedure for any course during summer term will be the same as those during regular semesters.

Students with U grades will have the option either to write semester end arrears exam or to redo the courses during summer / regular semesters, if they wish to improve their continuous assessment marks subject to the approval of the Head of the department.

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

12.5 The summer term courses are not applicable for the students of Part Time mode.

13.0 ASSESSMENTS AND EXAMINATIONS

13.1 The following rule shall apply to all the PG programmes (M. Tech. / M.C.A. / M.Sc.)

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

13.2 There shall be one examination of three hours duration, at the end of the semester.

13.3 In one (or) two credit courses that are not spread over the entire semester, the evaluation will be conducted at the completion of the course itself. Anyhow approval for the same is to be obtained from the HoD and the Dean of Academic Affairs.

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

13.5 At the end of industrial internship, the student shall submit a certificate from the organization and also a brief report. The evaluation will be made based on this report and a Viva-Voce Examination, conducted internally by a Departmental Committee constituted by the Head of the Department.

14.0 WEIGHTAGES

14.1 The following shall be the weightages for different courses:

i) Lecture based course

Two continuous assessments	50%
Semester-end examination	50%

ii) Laboratory based courses

Laboratory work assessment	75%
Semester-end examination	25%

iii) Project work

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

14.2 Appearing for semester end examination for each course (Theory and Practical) is mandatory and a student should secure a minimum of 40% marks in semester end examination for the successful completion of the course.

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

15.0 SUBSTITUTE EXAMINATION

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

15.2 A student who misses any assessment in a course shall apply in a prescribed form to the Dean (Academic Affairs) through the Head of the department within a week from the date of missed assessment. However

the substitute tests and examination for a course will be conducted within two weeks after the last day of the semester-end examinations.

16.0 COURSEWISE GRADING OF STUDENTS AND LETTER GRADES

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

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

- Flexible range grading system will be adopted
- **“W”** denotes withdrawal from the course.
- **"I"** denotes inadequate attendance and hence prevention from semester-end examination
- **"U"** denotes unsuccessful performance in a course.
- **“AB”** denotes absent for the semester end examination

16.2 A student is considered to have completed a course successfully if he / she secure five grade points or higher. A letter grade ‘U’ in any course implies unsuccessful performance in that course.

16.3 A course successfully completed cannot be repeated for any reason.

17.0 AWARD OF LETTER GRADE

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

17.2 After finalization of the grades at the class committee meeting the Chairman will forward the results to the Controller of Examinations, with copies to Head of the Department and Dean (Academic Affairs).

18.0 DECLARATION OF RESULTS

18.1 After finalization by the Class Committee as per clause 16.1 the Letter grades awarded to the students in the each course shall be announced on the departmental notice board after duly approved by the Controller of Examinations.

18.2 In case any student feels aggrieved about the results, he/she can apply for revaluation after paying the prescribed fee for the purpose, within one week from the announcement of results.

A committee will be constituted by the concerned Head of the Department comprising of the Chairperson of the concerned Class Committee (Convener), the teacher concerned and a teacher of the department who is knowledgeable in the concerned course. If the Committee finds that the case is genuine, it may jointly revalue the answer script and forward the revised marks to the Controller of Examinations with full justification for the revision, if any.

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

19.0 COURSE REPETITION AND ARREARS EXAMINATION

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

19.2 A student who is awarded “U” or “AB” grade in a course shall write the semester-end examination as arrear examination, at the end of the next semester, along with the regular examinations of next semester courses.

19.3 A student who is awarded “U” or “AB” grade in a course will have the option of either to write semester end arrear examination at the end of the subsequent semesters, or to redo the course whenever the course is offered. Marks earned during the redo period in the continuous assessment for the course, will be used for grading along with the marks earned in the end-semester (re-do) examination.

19.4 If any student obtained "U" or "AB" grade, the marks earned during the redo period for the continuous assessment for that course will be considered for further appearance as arrears.

19.5 If a student with "U" or "AB" grade prefers to redo any particular course fails to earn the minimum 75% attendance while doing that course, then he/she will not be permitted to write the semester end examination and his / her earlier 'U' grade and continuous assessment marks shall continue.

20.0 GRADE SHEET

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

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

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

(iii) the total credits earned in that semester.

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

20.2 The GPA will be calculated according to the formula

$$GPA = \frac{\sum_{i=1}^{n}(C_i)(GP_i)}{\sum_{i=1}^{n}(C_i)}$$

where n = number of courses

where C_i is the number of credits assigned for i^{th} course

GP_i - Grade point obtained in the i^{th} course

for the cumulative grade point average (CGPA) a similar formula is used except that the sum is over all the courses taken in all the semesters completed up to the point of time.

'I' and 'W' grades will be excluded for GPA calculations.

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

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

20.3.1 For students under full time mode of study

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

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

20.3.2 For students under part time mode of study

CGPA	Classification
8.50 and above, having completed all courses in first appearance	First class with Distinction
6.50 and above	First Class
All others	Second Class

For the purpose of classification, the CGPA will be rounded to two decimal places.

21.0 ELIGIBILITY FOR THE AWARD OF THE MASTERS DEGREE

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

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

ii) no disciplinary action is pending against him/her.

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

22.0 POWER TO MODIFY

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

CURRICULUM & SYLLABI FOR
M. Tech (Power Electronics and Drives)

CURRICULUM
(FOUR SEMESTERS / FULL TIME)

Sl. No.	Course Code	Course Title	L	T	P	C
		SEMESTER I				
1	MAC6184	Probability, Matrix Theory And Linear Programming	**3**	**1**	**0**	**4**
2	EEC6125	Modeling and Analysis of Electrical Machines	**3**	**0**	**0**	**3**
3	EEC6126	Advanced Power Semiconductor Devices	**3**	**0**	**0**	**3**
4	EEC6127	Analysis of Power Converters	**3**	**0**	**0**	**3**
7	EEC6128	Embedded Control of Electric Drives	**3**	**0**	**2**	**4**
8		Professional Elective @				**3@**
9	EEC6129	Simulation of Power Electronic Systems - Laboratory	**0**	**0**	**3**	**1**
10	EEC6130	Design / Fabrication Lab	**0**	**0**	**3**	**1**
		Total Credits				**22**
		SEMESTER II				
1	EEC6235	Solid State AC and DC Drives	**3**	**0**	**0**	**3**
2	EEC6236	Analysis of Power Inverters	**3**	**0**	**0**	**3**
3	CSB6101	Research Methodology for Engineers	**3**	**1**	**0**	**4**
4		Professional Electives #				**9#**
5	EEC6238	Power Electronics and Drives Laboratory	**0**	**0**	**3**	**1**
6	EEC6239	Self Learning	**0**	**2**	**0**	**2**
7	EEC6240	Industrial Internship	**0**	**0**	*****	******
		Total Credits				**22**
		SEMESTER III				
1	EEC6240	Industrial Internship	**0**	**0**	*****	**2**
2		General Elective @				**3 @**
3		Professional Elective @				**3 @**
4	EEC7111	Project Work - Phase I ##	**0**	**0**	**12**	**6##**
		Total Credits				**8**

SEMESTER IV

1	EEC7111	Project work - Phase II ##	**0**	**0**	**36**	**18**
						18+6=24
		Total Number of Credits				**76**

* Minimum 30 days of industrial internship

** Industrial internship will be undertaken during first year summer vacation. The credit will be awarded in the 3rd semester.

@ Minimum of 3 credits

Minimum of 9 credits

Credits for Project Work Phase I to be accounted along with Project Work Phase II in IV Semester.

PROFESSIONAL ELECTIVE

Sl. No.	Course Code	Course Title	L	T	P	C
1	EECY004	Power Quality	**3**	**0**	**0**	**3**
2	EECY006	Advanced Digital Signal Processing	**3**	**0**	**0**	**3**
3	EECY011	High Voltage Direct Current Transmission	**3**	**0**	**0**	**3**
4	EECY012	Wind Energy Conversion Systems	**3**	**0**	**0**	**3**
5	EECY015	Flexible AC Transmission Systems	**3**	**0**	**0**	**3**
6	EECY018	Smart Power Grid	**3**	**0**	**0**	**3**
7	EECY019	Distributed Generation and Micro Grid	**3**	**0**	**0**	**3**
8	EECY041	Digital Signal Processors	**3**	**0**	**0**	**3**
9	EECY042	Robotics And Factory Automation	**3**	**0**	**0**	**3**
10	EECY043	SCADA and DCS	**3**	**0**	**0**	**3**
11	EECY044	Spacecraft Power Systems	**3**	**0**	**0**	**3**
12	EECY045	Modern Electric, Hybrid Electric And Fuel Cell Vehicles	**3**	**0**	**0**	**3**
13	EECY046	Transformers and Inductors for Power Electronics	**3**	**0**	**0**	**3**
14	EECY047	Special Electrical Machines and Controllers	**3**	**0**	**0**	**3**
15	EECY048	Vector Control of AC Drives	**3**	**0**	**0**	**3**
16	EECY049	Solar and Energy Storage Systems	**3**	**0**	**0**	**3**
17	EECY050	Fundamentals of Grid Connected Photo Voltaic Power Electronic Converter Design	**3**	**0**	**0**	**3**
18	EECY051	Solar Power System Design	**3**	**0**	**0**	**3**
19	EECY052	Switched Mode Power Conversion Systems	**3**	**0**	**0**	**3**
20	EEC6101	System theory	**3**	**0**	**0**	**3**

GENERAL ELECTIVES FOR M.TECH PROGRAMMES

Sl. No.	Course Code	Course Title	L	T	P	C
1	GECY101	Project Management	**3**	**0**	**0**	**3**
2	GECY102	Society, Technology & Sustainability	**3**	**0**	**0**	**3**
3	GECY103	Artificial Intelligence	**3**	**0**	**0**	**3**
4	GECY104	Green Computing	**3**	**0**	**0**	**3**
5	GECY105	Gaming Design	**3**	**0**	**0**	**3**
6	GECY106	Social Computing	**3**	**0**	**0**	**3**
7	GECY107	Soft Computing	**3**	**0**	**0**	**3**
8	GECY108	Embedded System Programming	**3**	**0**	**0**	**3**
9	GECY109	Principles of Sustainable Development	**3**	**0**	**0**	**3**
10	GECY110	Quantitative Techniques in Management	**3**	**0**	**0**	**3**
11	GECY111	Programming using MATLAB & SIMULINK	**1**	**0**	**2**	**2**
12	GECY112	JAVA Programming	**1**	**0**	**2**	**2**
13	GECY113	PYTHON Programming	**1**	**0**	**2**	**2**
14	GECY114	Intellectual Property Rights	**1**	**0**	**0**	**1**

SEMESTER I

		L	T	P	C
MAC6184	**PROBABILITY, MATRIX THEORY AND LINEAR PROGRAMMING**	**3**	**1**	**0**	**4**

OBJECTIVE:

The aim of this course is to

- provide a comprehensive introduction to the probability distributions used in engineering.
- familiarize students with advanced matrix theory and variation problems.
- expose the students to Operations Research using concepts of linear programming.

MODULE I PROBABILITY DISTRIBUTIONS 10

Axioms of probability – addition and multiplication theorem – conditional probability –total probability – random variables - moments – moments generating functions and their properties- Binomial, Poisson, Geometric, Uniform, Exponential and Normal distributions.

MODULE II TWO DIMENSIONAL RANDOM VARIABLES 08

Joint distributions - marginal and conditional distributions - functions of random variables - covariance - correlation and regression - Central limit theorem.

MODULE III ADVANCED MATRIX THEORY 09

Matrix norms - singular value decomposition - QR algorithm - pseudo inverse - least square approximations.

MODULE IV LINEAR PROGRAMMING 10

Formation - graphical method - simplex method - Big-M method - Two Phase method - transportation and assignment problems.

MODULE V CALCULUS OF VARIATIONS 08

Variation and its properties – Euler's equation – functional dependant on first and higher order derivatives – functional dependant on functions of several independent variables – variational problems with moving boundaries – isoperimetric problems – Ritz and Kantorovich methods.

L – 45; T – 15; Total Hours: 60

TEXT BOOKS:

1. S.M.Ross, “A First Course in Probability”, 9th edition, Pearson Education, 2013.
2. Lewis.D.W., “Matrix Theory”, Allied Publishers, Chennai, 1995.
3. Taha, H.A., “Operations Research - An Introduction '', 10th edition, Pearson Prentice Hall, 2016.
4. A.S. Gupta, “Calculus of variations with applications”, PHI Pvt. Ltd, New Delhi, 2011.

REFERENCES:

1. H. Cramer., “Random Variables and Probability Distributions”, Cambridge University Press (2004).
2. Roger A. Horn, Charles R. Johnson, “Matrix Analysis”, Cambridge University Press; 2nd edition (2012).
3. Robert.J.Vanderbei., “Linear Programming: Foundations and Extensions”, Springer US(2014).
4. David. J. Rader., “Deterministic Operations Research”, Wiley (2010).
5. Elsgolts, “Differential Equations and Calculus of Variations", University Press of the Pacific (2003).

OUTCOME:

At the end of the course students will be able to

- Solve problems using concept of standard, discrete and continuous distributions.
- Solve problems using one dimensional and two dimensional random variables.
- Find Eigen values and Eigen vectors of a higher order matrix.
- Solve problems of linear programming.
- Solve problems of calculus of variations by direct methods and using Euler’s formulae.

EEC 6125	MODELING AND ANALYSIS OF ELECTRIC MACHINES	L	T	P	C
		3	0	0	3

OBJECTIVE:

- To give an in-depth input on generalized theory of electric machines.
- To impart knowledge on the Modeling aspects of reference frame theory and transformational variables of electrical machines using reference frame theory.
- To impart knowledge on Analysis of electric machines using the reference frame theory model.
- Prediction of torque and other related variables for static and dynamic analysis of electric machines.

MODULE I PRICIPLE OF ELECTOMAGNETIC ENERGY CONVERSION 07

Stored magnetic energy – Co-energy – flux-linkage vs current curves – Singly excited and Doubly excited systems – Force and Torque predictions.

MODULE II BASIC CONCEPTS OF ELECTRIC MACHINES 07

Generalized theory of electric machines – Concept of d-q model – Kron's Primitive Model – Airgap MMF, Per phase machine inductance, Voltage and Torque equations for DC machine and AC machines.

MODULE III MODELING AND ANALYSIS OF DC MACHINES 09

Static and Rotating reference frames and Transformation Relationships – R, L, M, V, I and T equations using direct and quadrature axes in: Modeling of separately excited DC machines – Modeling of DC series machines – Influence of brush shift.

MODULE IV REFERENCE FRAME THEORY FOR 3-PHASE INDUCTION MACHINES 09

Modeling of 3-phase symmetrical induction machines – V, I, L and T equations in actual variables and hypothetical variables – Rotor transformation – V, I, L and T equations in transformed machine.

MODULE V REFERENCE FRAME THEORY FOR 3-PHASE SYNCHRONOUSMACHINES 08

Modeling of Synchronous Machines – Determination of self inductances and mutual inductances – Transformation of self inductances and mutual inductances – Dynamic Modeling of AC machines.

MODULE VI MODELING OF SPECIAL ELECTRIC MACHINES 05

Modeling aspects of Magnetic Systems – Modeling Switched Reluctance Machines – Case Study (Modeling of DC and AC machines.)

Total Hours: 45

REFERENCES:

1. C.V. Jones, 'The Unified Theory of Electric Machines', Butterworth, London, 1967
2. R. Krishnan, 'Switched Reluctance Motor Drives', CRC Press.
3. MAGNET software rule book for Case study purpose.

OUTCOMES:

- Ability to understand the rudiments of electric machines for modeling and analysis.
- Ability to apply generalized machine theory for DC and AC machine modeling.
- Ability to apply Reference Frame theory for DC and AC machine modeling and analysis.
- Ability to model and analyze any new electric machine.
- Ability to use modeling software tools for machine modeling and analysis.

EEC 6126	ADVANCED POWER SEMICONDUCTOR DEVICES	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the basics of devices selection.
- To understand the static and dynamic characteristics of power semiconductor devices
- To enable the students for the selection of devices for different power electronics applications
- To get the knowledge about the datasheet of power semiconductor Devices.
- To understand the control and firing circuit for different devices.
- Study about the thermal protection of the Devices

MODULE I INTRODUCTION 06

Power switching devices overview; Attributes of an ideal switch, application requirements, and circuit symbols. Power handling capability, Device selection strategy – On-state and switching losses -Power diodes - Types, forward and reverse characteristics, switching characteristics – rating.

MODULE II SILICON POWER ELECTRONIC SEMICONDUCTORS DEVICES and DRIVER CIRCUITS 10

Construction, static characteristics, switching characteristics and Gate characteristics of Thyristor – GTO – MOSFET- IGBTs – SIC – GAN – FCT – RCT. Converter grade and inverter grade SCR. High Speed Opto-Couplers – Zero Crossing Detectors - Optically Isolated High Voltage and High Current sensing circuits, Driver ICs**:** MOC series SCR , IR2XXX Series Full Bridge and Half Bridge MOSFET / IGBT Driver ICs.

MODULE III DATASHEET RATINGS FOR SEMICONDUCTOR DEVICES 09

Standards, Symbols and terms-Maximum ratings – Thermal Impedance and resistance-Component (type) designation system - Mechanical data –Safe Operating Area during switching and short circuit.

MODULE IV PROTECTION AND NOISE 07

Over voltage, Over current and gate protections and Design of snubber circuits - Noise generated due to switching-Common noise sources in SMPS-Noises Due to High frequency transformer-Measurement of Noise.

MODULE V THERMAL PROTECTION 07

Heat transfer – conduction, convection and radiation, Cooling – liquid cooling, vapour – phase cooling, Guidance for heat sink selection- heat sink types and design-Electrical analogy of thermal components– Mounting types.

MODULE VI CASE STUDY 06

Switching characteristics and VI characteristics of Thyristor – GTO – MOSFET-IGBTs – SIC – GAN. Design of drivers and Snubber Circuit.

Total Hours: 45

REFERENCES:

1. Rashid M.H., “Power Electronics circuits, Devices and Applications”, Prentice Hall India, Third Edition, New Delhi, 2008.
2. M.D. Singh and K.B.Khanchandani, “Power Electronics”, Tata McGraw Hill, 2006.
3. Vedam Subramanian, "Power Electronics", New Age International (P) Limited, New Delhi, 1997.
4. Ned Mohan, Undcland and Robins, “Power Electronics – Concepts, applications and Design, John Wiley and Sons, Singapore, 2000.
5. B.W. Williams, “Power Electronics – Devices, Drivers, Applications and Passive Components”, Macmillan, 1992.
6. Dr.-Ing. Arendt Wintrich,Dr.-Ing. Ulrich Nicolai,Dr. techn. Werner Tursky,Univ.-Prof. Dr.-Ing. Tobias Reimann,Application Manual Power Semiconductors ,published by SEMIKRON International GmbH

OUTCOMES:

At the end of the course, the student will

- Understand the operation and characteristics of the semiconductor devices
- Understand the gate drive circuits and its necessity.
- Select suitable component for the particular application with the help of data sheet.
- Design protection circuit for the semiconductor devices.
- Design heat sinks for semiconductor devices

EEC 6127 ANALYSIS OF POWER CONVERTERS

L	T	P	C
3	0	0	3

OBJECTIVES:

- To impart knowledge, analyze and to design the power Electronic converters.
- To discuss in depth the main families of PWM strategies.
- To enable the students to design Power Factor Correction (PFC) controller.

MODULE I AC – DC CONVERTER 08

Circuits and operating principles: Analysis of Single phase and three phase controlled rectifiers with RLE loads - Input line current harmonics and power factor – Fourier Analysis of controlled rectifiers - Dual converters.

MODULE II PERFORMANCE CHARACTERISTICS OFPHASE CONTROLLED CONVERTERS 08

Performance parameters: Dc voltage ratio – input displacement angle – displacement factor - power factor – current distortion factor- Harmonic content of DC terminal voltage and input current - THD of Two quadrant converters and one quadrant converters - reduction of reactive loading of the supply by the Two quadrant converter by means of consecutive firing angle control.

MODULE III PHASE CONTROLLED CYCLOCONVERTER 08

Symmetrical - open delta - Ring connected cycloconverter circuits - Harmonic distortion in the output voltage – General Expression for Three pulse waveform for an arbitrary firing angle control method - Harmonic series of three and six pulse cycloconverters – cosine wave control method – Firing pulse generation: Functional schemes – End stop control : reference voltage - clamp method – pulse isolating output stage.

MODULE IV AC – AC CONVERTERS 07

Analysis of Single-phase and Three phase AC Voltage Controllers- Matrix converter - Bi-directional switch topologies, Modulation techniques for matrix converters, Concept of Direct AC-AC frequency Converter.

MODULE V ACTIVE FRONT END RECTIFIERS 07

Overview of Power Factor Correction Approaches - Unity power factor rectifiers - Resistor emulation principle –mathematical modeling – control schemes- Design of feedback compensators -front end rectifiers with real and reactive power control

– Phase shifter.

MODULE VI DUAL ACTIVE BRIDGE CONVERTER 07

Dual active bridge converter – circuit configuration – steady state analysis – steady state model of DC-DC DAB Converters - Steady-State Model for AC-AC DAB Converters - soft switching analysis – DAB for Solid state transformer.

Total Hours: 45

REFERENCES:

1. M. H. Rashid, "Power Electronics - Circuits, Devices and Applications", Pearson Education India, 2003
2. Ned Mohan, Tore M. Undeland. "Power Electronics- Converters, Applications and Design", John Wiley & Sons (Asia) Private Ltd., 2003.
3. M.D.Singh, " Power Electronics"Tata McGraw-Hill Education, 07-Jul-2008.
4. Eric Monmasson, Power Electronic *Converters* PWM Strategies and Current Control Techniques, John Wiley & Sons, Inc, © ISTE Ltd 2011.
5. ON Semiconductor "Power Factor Correction (PFC) Handbook", HBD853/D Rev. 5, Apr−2014.
6. D.M.Mitchell, DC-DC Switching Regulator Analysis McGraw-Hill Ryerson, Limited, 1988.

OUTCOMES:

At the end of the course, the student is expected to possess knowledge and achieve skills on the following

- Understand the concept of Converters, choppers, and AC voltage controllers.
- Select the suitable devices for the required applications in power Electronic controller for rectification, inversion, frequency conversion.
- Analyze the performance parameters of the converter circuit.
- Provides a comprehensive overview of PFC circuits and details of operation and design considerations for commonly used PFC circuits.
- Able to learn more about advanced power electronics converters.

EEC 6128	EMBEDDED CONTROL OF ELECTRIC DRIVES	L	T	P	C
		3	0	2	4

OBJECTIVES:

- The objective of this course is to introduce embedded application design for Electrical Drives.
- To provide practical experience with microcontroller systems
- Introduces Mikro C compiler for 16 series PICs.
- Demonstrates the use of the PIC Microcontrollers for Electrical Drives.

MODULE I PIC16F8XX- MICROCONTROLLERS 04

Device Overview- Features and Function- Core SFRs- I/O Ports- Timers-CCP MODULEs- Serial Communication MODULEs- Analog MODULEs - Internal oscillator - External oscillator in LP, XT or HS, RC and RCIO modes – EEPROM – Watch Dog Timer- Black-out and Brown-out Resets.

MODULE II MIKRO C COMPILER 05

Mikro C Compiler reference- Valid C Characters- Variables- Constants- Types- Increment and decrement - structure-Operators and expressions-Loops- Conditionals-micro C Libraries- ADC, CAN, CANSPI, EEPROM, Ethernet, PWM, Keypad, LCD, SPI Ethernet, RS485,USART and Trigonometric Libraries - Preprocessor- Statements.

MODULE III MIKRO C BUILDING APPLICATIONS 05

Mikro C IDE : Code Editor- Code Explorer – Debugger – Error Window – Statistics – Integrated Tools - Building applications :Projects – Source Files :Search Paths – Managing Source Files – Compilation : Output Files – Assembly View – Error Messages.- Flashing Software : Overview of PICkit2.

MODULE IV ALGORITHM AND PROGRAMMING IN MIKROC 20

Digital realization of error amplifier, limiter and Proportional-Integral-Derivative (PID) controller - PID algorithm - Source codes in Mikro C: ADC and PWM – SVPWM – Unipolar and Bipolar SPWM – Phase Angle Control with Zero Crossing Detection.

MODULE V MICROCONTROLLER COMMUNICATION 06

PIC to PIC Communication using UART - Communication with RS232 Serial Bus - Interfacing EEPROM -I²C Communication with PIC Microcontroller - Interfacing lcd and Temperature sensors - ZigBee communication between PICs.

MODULE VI CLOSED LOOP CONTROL OF ELECTRIC DRIVES 20

Closed Loop Control of the Plant Model - Hardware and Software Implementation using PIC Microcontrollers: Speed control of Chopper fed separately excited DC Motor – AC Motor Control Using TRIAC Phase Controller, SPWM and SVPWM inverter fed induction motor - Stepper Motor Interfacing – Servo Motor control.

L: 45, T: 50, Total Hours: 60

REFERENCES:

1. John Main, “PIC Microcontroller C”, 2006-2007 Edition, 2007.
2. Mikro C- Compiler for PIC Microchip controllers- mikro Electronik, 2012.
3. Martin P. Bates,” Programming 8-bit PIC Microcontrollers in C: With Interactive Hardware Simulation. Tim Wilmshurst “Designing Embedded Systems with PIC Microcontrollers- Principles and applications”
4. Martin P. Bates,” PIC Microcontrollers –An Introduction” Newnes,2011.
5. Dogan Ibrahim, “Advanced PIC Microcontroller Projects in C: From USB to RTOS”, Elsevier Ltd, 2008.
6. Han-Way Huang, Leo Chartrand, "PIC Microcontroller: An Introduction to Software & Hardware Interfacing", Delmar Cengage Learning, 2004.

OUTCOMES:

At the end of the course, the student is expected to possess knowledge and achieve skills on the following:

- Work on different projects making use of the PIC microcontroller
- Implement external interfaces in various embedded system projects by using various interfacing techniques.
- Enable the student to design software to interact with real-world systems
- Design and develop both the hardware and software microcontroller based Electric Drive systems.
- Develop and demonstrate how to accomplish a given task using Embedded “C” language on a microcontroller.
- Demonstrate a working knowledge of the necessary steps and methods used to interface a microcontroller system to devices such as motors, sensors, etc.

EEC 6129	SIMULATION OF POWER ELECTRONIC SYSTEMS LABORATORY	L	T	P	C
		0	0	3	1

OBJECTIVES:

The aim of this course is

- To enable the students to understand the modeling details of Power electronic Components and circuits in detail.
- To understand the behavior of controlled rectifier circuits for different types of electrical loads and the working of different type of Power Electronic Converters.
- To learn different gating circuits for converters turn-on.
- To understand the control methods of inverters and choppers.

LIST OF EXPERIMENTS

MATLAB / SIMULINK BASED EXPERIMENTS

1. Switching Characteristics of MOSFET and Diode.
2. Step-Down (Buck) DC-DC Converters. Step-Up (Boost) DC-DC Converter.
3. Step-Down/Up (Buck-Boost) DC-DC Converter .
4. Three phase controlled Rectifiers with R-L-E loads.
5. Single phase inverter with PWM control.
6. Three phase inverter with PWM control.
7. Single phase AC voltage regulator.
8. Single phase cycloconverter.

PSIM BASED EXPERIMENTS

1. Frequency Response Analysis of a Buck Converter using an Averaged Model.
2. Designing the Feedback Control for a Buck Converter using the Voltage-Mode Control.
3. Flyback DC-DC Converter.
4. Full-Bridge DC-DC Converters.
5. TRIAC based phase angle controller.
6. Closed loop speed control of dc motor using PID controller.

Total Hours: 45

OUTCOMES:

At the end of the course, the student will be able to

- Model & Simulate the Power Electronic Components and Circuits using various Simulation Softwares.
- Select a suitable power electronic device for different applications.
- Analyze the all types of converters by using simulation
- Regulation of output voltage using converters.
- Design a closed control of Motor drives.

EEC 6130 DESIGN / FABRICATION LAB

L	T	P	C
0	0	3	1

OBJECTIVES:

To prepare students to design and fabricate power electronics circuitry for various electrical applications.

- Applying tools and methodologies of a field of practice in a design project
- Developing knowledge of organizational and social contexts of a chosen field of practice

LIST OF EXPERIMENTS:

1. Design and fabrication of Zero Crossing Detector for Phase angle Controllers.
2. Fabrication of Optically isolated gate driver circuit for Phase angle Controllers.
3. Design and fabrication of TRIAC Phase angle Controller.
4. Design and fabrication of controlled Rectifiers.
5. Fabrication of Optically Isolated MOSFET /IGBT Driver circuit.
6. Design and fabrication of Buck converter.
7. Design and fabrication of Boost converter.
8. Design and fabrication of PWM based AC choppers.
9. Design and fabrication of Half Bridge Driver circuit for MOSFET/ IGBT.
10. Fabrication of self-Oscillating gate driver circuit for MOSFET/ IGBT.
11. Fabrication of Three phase gate driving stage for three phase Inverters.
12. Fabrication of single phase full bridge Inverter.

Total Hours: 45

OUTCOMES:

At the end of the course, the student is expected to possess knowledge and achieve skills on the following:

- Awareness of the impact of Power Electronic circuits on utility supply
- The students are assessed on their performance in meeting the criteria of Open-ended, design-oriented labs. Three small projects have to be designed, built and tested. The students should justify their design.
- Ability to build power electronic circuits
- Ability to read and understand datasheets of power electronic devices and related ICs
- Ability to build Micro Inverters for solar power generation.

SEMESTER II

EEC 6235	SOLID STATE AC AND DC DRIVES	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the stable steady-state operation and transient dynamics of a motor-load system.
- To study and analyze the operation of the converter / chopper fed dc drive and to solve simple Problems.
- To study and understand the operation of both classical and modern induction motor drives.
- To understand the differences between synchronous motor drive and induction motor drive and to learn the basics of permanent magnet synchronous motor drives with converter.
- To analyze and design the current and speed controllers for a closed loop solid-state DC and AC motor drive and simulation using a software package

MODULE I FUNDAMENTAL OF DC AND AC MOTOR 06

Components of electrical Drives-electric machines, power converter, controllers-dynamics of electric drive - torque equation - equivalent values of drive parameters - components of load torques types of load - four quadrant operation of a motor– steady state stability– load equalization – classes of motor duty - determination of motor rating.

MODULE II SENSORS FOR DRIVES 06

Hall Effect Sensors – Mechanical Sensors for speed and angular positions – Absolute Encoders – Incremental Encoders – Resolvers

MODULE III CLOSED LOOP CONTROL OF DC AND AC DRIVES 09

Transient analysis of separately excited motor – converter control of dc motors – analysis of separately excited & series motor with 1 - phase and 3 - phase converters – dual converter – analysis of chopper controlled dc drives – converter ratings and closed loop control – transfer function of self, separately excited DC motors – linear transfer function model of power converters – sensing and feeds back elements – current and speed loops, P, PI and PID controllers – response comparison – simulation of converter and chopper fed DC drive.

MODULE IV SCALAR METHODS FOR IM DRIVES FROM STATOR SIDE 09

Stator voltage control of induction motor–torque-slip characteristics-operation with different types of loads – operation with unbalanced source voltages and single phasing – analysis of induction motor fed from non - sinusoidal voltage supply – stator frequency control - variable frequency operation – V/F control, controlled current and controlled slip operation – effect of harmonics and control of harmonics

MODULE V SCALAR METHODS FOR IM DRIVES FROM ROTOR SIDE 08

PWM inverter drives – multiquadrant drives – rotor resistance control – slip torque characteristic – torque equations, constant torque operation – slip power recovery scheme – torque equation – torque slip characteristics – power factor – methods of improving power factor – limited sub synchronous speed operation – super synchronous speed operation.

MODULE VI SYNCHRONOUS MOTOR DRIVES 07

Principle of synchronous motor control – Introduction to CSI Single phase and three phase CSI – CSI fed synchronous machines – adjustable frequency operation of synchronous motors –voltage source inverter drive with open loop control – self controlled synchronous motor with electronic commutation – self controlled synchronous motor drive using load commutated thyristor inverter.

Total Hours: 45

REFERENCES:

1. R. Krishnan, Electrical Motor Drives, PHI 2003.
2. G.K.Dubey, Powersemiconductor controlled drives, Prentice Hall- 2000.
3. G.K.Dubey, Fundamentals of Electrical Drives, Narosa-1999.
4. Nasar, Boldea , Electrical Drives, Second Edition, CRCPress-2006.
5. M. A. ElSharkawi , Fundamentals of Electrical Drives , Thomson Learning - 2000. 49
6. Vedam Subrahmaniam, Electric Drives, TMH-2000.

OUTCOMES:

At the end of the course, the student is expected to possess knowledge and achieve skills on the following: Analyse the system considering the steady state and dynamic characteristics.

- Abilty to design a closed loop control of AC and DC drives.
- Talent in selection of motor for various application.
- Software knowledge in matlab , for drive application.
- Modeling AC,DC machines with appropriate loads
- Design a system with suitable parameters to control a drive system.

EEC 6236 ANALYSIS OF POWER INVERTERS

L	T	P	C
3	0	0	3

OBJECTIVES:

- To impart knowledge, analyze modern inverters with improved performance.
- To prepare the students to analyze and design different power converter circuits.
- To understand the use of power converters in commercial and industrial applications.
- To identify basic requirements for power electronics based design application

MODULE I SINGLE PHASE INVERTERS 08

Principle of operation of half and full bridge inverters with R and RL loads – Performance parameters –Steady –state Analysis and Fourier Analysis of Single – phase Inverter.

MODULE II THREE PHASE VOLTAGE SOURCE INVERTERS 07

180 degree and 120 degree conduction mode inverters with star and delta connected loads- Steady –state Analysis and Harmonics Analysis of Three – phase Inverters.

MODULE III PWM STRATEGIES AND VOLTAGE CONTROL 07

Single-pulse Modulation, Multiple-pulse Modulation, Sinusoidal – Pulse Modulation (sin M), Reduction of Harmonics in the Inverters Output Voltage, Harmonic Reduction By PWM - Voltage control of three phase inverters: sinusoidal, space vector modulation (SVPWM) techniques.

MODULE IV MULTILEVEL INVERTERS 07

Multilevel concept –Comparison of multilevel inverters - application of multilevel inverters - Diode clamped – flying capacitor – cascade type multilevel inverters - PWM for multilevel inverters

MODULE V RESONANT INVERTERS 08

Series and parallel resonant inverters - zero current and Zero voltage switching resonant converters, frequency response.

MODULE VI GRID TIE INVERTER 08

Phase locked loop for synchronization, P-Q Control - Structure of the VSI PQ

Controller - Power-Voltage (PV) Control Scheme - Frequency (V/f) Control Scheme - generation Control based on droop Concept - adaptive droop control.

Total Hours: 45

REFERENCES:

1. M. H. Rashid, "Power Electronics - Circuits, Devices and Applications", Pearson Education India, 2003
2. Ned Mohan, Tore M. Undeland. "Power Electronics- Converters, Applications and Design", John Wiley & Sons (Asia) Private Ltd., 2003.
3. M.D.Singh , " Power Electronics"Tata McGraw-Hill Education, 07-Jul-2008
4. R W Erickson and D Makgimovic,"Fundamental of Power Electronics"Springer, 2001 2nd Edition.
5. Vedam Subrahmanyam, "Power Electronics", New Age International (P) Limited, New Delhi, 1997.
6. D.M.Mitchell, DC-DC Switching Regulator Analysis McGraw-Hill Ryerson, Limited, 1988

OUTCOMES:

At the end of the course, the student is expected to possess knowledge and achieve skills on the following

- Ability to analyze the operation of single and three phase inverters.
- Select the suitable devices for the required applications in power Electronic controller for inversion, frequency conversion.
- Ability to determine the performance parameters of single phase and three phase inverters.
- Ability to design a PWM control of inverter.
- Design and implement multi level and resonant inverter.
- Know the control aspects of grid tied inverters

CSB6101	RESEARCH METHODOLOGY FOR ENGINEERS	L	T	P	C
		3	1	0	4

OBJECTIVES:

- To make the students well versed in statistical methods used in engineering.
- To describe the steps involved in research process.
- To explain how to formalize research problems.
- To discuss clearly the approaches for research through some case studies.

MODULE I RESEARCH PROBLEM 08

The research problem – Sources of research problem – Information, how to deal with it – Criteria / characteristics of a good research problem – Errors in selecting a good research problem – Types of research – Nature and use of arguments.

MODULE II ANALYSIS OF VARIANCE 07

Anova – one way – two way classification – Collection of Secondary Latin square design – 2^2 factorial design.

MODULE III DESIGN OF EXPERIMENTS 08

Experimental factors – interaction of factors, Types of experimental design – blocking design – factorial – fractional factorial, Taguchi's orthogonal approach.

MODULE IV REGRESSION, CORRELETION AND CURVE FITTING 10

Regression analysis – simple linear regression – regression coefficient, multiple regression – multiple & partial correlation coefficient, curve fitting – graphical – least square – method testing of goodness of fit.

MODULE V TRANSPORTATION AND ASSIGMENT MODELS 06

Transportation Problem – Assignment Problem – Travelling Sales man. Problem.

MODULE VI CASE STUDIES 06

Presentation by students on their area of research.

L: 45, T: 15, Total Hours: 60

REFERENCES:

1. Kothari, C.R., "Research Methodology: Methods and Techniques", 2nd Edition, New Age International, New Delhi, 2012.
2. Nicholas Walliman, "Your Research Project", 2nd Edition, Vistaar

Publication, New Delhi, 2005.
3. Taha H.A., “Operations Research: An Introduction”, 7th Edition, Pearson Education Edition, Asia, New Delhi, 2002.
4. Richard A. Johnson, “Miller and Freund’s Probability and Statistics for Engineers”, 8th Edition, Pearson Education, Asia, 2011.

OUTCOMES:

Students who complete this course will be able to

- Identify the research problem.
- Become capable of analyzing the data using mathematical techniques.
- Learn to apply the statistical concepts in research.
- Demonstrate the different research methods applicable to a specific problem.

EEC 6238	POWER ELECTRONICS AND DRIVES LABORATORY	L	T	P	C
		0	0	3	1

OBJECTIVES:

- To understand the design and modelling of Electric drives in detail
- To enable the student to obtain a firm grasp of various Power Electronic Circuits and their practical applications in drives.
- To acquire knowledge of the application of Embedded Controllers to the conversion and control of electrical energy.
- To perform the experiments on various motor drive applications.

LIST OF EXPERIMENTS

1. Fabrication of Chopper fed DC drive using PIC 16F877A micro controller.
2. Brushed DC motor drive with C2000 Piccolo F28035 MCU control CARD
3. Closed loop control of Chopper fed DC motor drive using PIC 16F877A micro controller.
4. Stepper motor drive with C2000 Piccolo F28035 MCU control CARD.
5. Three phase brushless DC motor- sensor less field oriented/vector control (FOC) using C2000 Piccolo TMS320F28069M and TMS320F28027F MCU DSPs
6. Three phase Induction motor drive using Hercules RM42L432- dual core ARM Cortex-R4 based MCU.
7. PSIM interfaced Piccolo docking station that features on board USB JTAG emulation with F28035 control CARD
8. Inverter fed Induction motor drive using Intelligent Power Module 3-phase IGBT inverter IC with integral gate drivers.
9. Lab VIEW controlled AC and DC drives.

Total Hours: 45

OUTCOMES:

At the end of the course, the student is expected to possess knowledge and achieve skills on the following:

- This course allows the students to gain knowledge in advanced controllers.
- Power electronics circuit design, control systems, and a tremendous range of sub-areas.
- Strong experience of design with embedded processors and peripherals.
- Experience of real-time application programming and embedded operating system.
- To fabricate complete AC and DC Drives.

EEC6239	SELF LEARNING	L	T	P	C
		0	2	0	2

OBJECTIVE:

- To provide fundamental and advanced knowledge in the area of final year project work the student intends to do.

COURSE DESCRIPTION:

A student is expected to do the self learning course on his own, relating to the area of Project work. For discussion and interaction with the project supervisor, two hours per week is allocated. The course content and the materials for self learning course shall be decided by the student and the respective supervisor and the same will be approved by the Head of the Department. A broader choice will be given to the student so that a student is permitted to choose a course in the areas of his/her interest.

OUTCOME:

At the end of the course, the student will be able to

- understand research papers through self learning
- self enquiry the technical advancements in the field of power electronics and drives
- Narrow down the area of project work to focus on specific topic.
- Acquire sufficient fundamental and advanced knowledge to carry out the project work.
- Under take any such new ideas on his/her own

EEC 6240	INDUSTRIAL INTERNSHIP	L	T	P	C
		0	0	*	**

* Minimum of 30 days Industrial Internship.

** Industrial internship will be undertaken during first year summer vacation. Two credits will be awarded in the 3rd semester.

OBJECTIVE:

- To provide fundamental and advanced knowledge in the area of Power Electronics and Drives.
- To provide an experience in the work culture of industries

COURSE DESCRIPTION:

- To earn credits for this course, a minimum 30 days of industrial training, in a single slot, is mandatory. The course has to be undertaken during the first year summer vacation and the credits will be awarded in the third semester.
- If the student is not able to complete the internship during the first year summer vacation, he/she can complete the course in a single slot between 2nd and 4th semester vacation.
- For effective implementation of the course Industry Internship, a teaching faculty is appointed as the coordinator by the Head of the department.
- The students will be allowed to undergo training only in reputed companies/research labs/design centres. The co-ordinator identifies the companies related to core engineering for internship during second semester. He/she assists the students in every process of getting into the companies as an intern.
- To enable the students to focus on the internship, no two students are allowed to be in the same site.
- Interacting with the respective industries, where the students do their internship, the Coordinator continuously monitors the performance of the students during the internship.
- After completion of the internship, the students are required to submit a detailed report and present what they had learned through the internship, in the form of posters. The students should submit the industry certificate at the time of giving the presentation.
- The performance of the student will be evaluated by the industry as well as the University. Both the evaluations will be considered and aggregated to award the final grade. 50% weightage is given to the evaluation by the

industry and remaining 50% weightage to the evaluation by the committee appointed by the Head of the Department.

- The 50 % weightage of evaluation done at the department comprises of (a) 20/50 for viva-voce, (b) 20/50 for the Intern report and (c) 10 /50 for poster presentation.

OUTCOME:

At the end of the course, the student will be able to

- Solve problems typically encountered by engineers in industry.
- Identify and address social, economic, and safety issues in an engineering problem and develop a solution that addresses this.
- Learn new concepts and apply them to the solution of engineering problems.
- Function effectively on a multidisciplinary team and interface effectively with other areas of the organization.
- Clearly communicate their ideas orally and in writing.
- Prepare for a lifelong productive career as an engineer.

SEMESTER III

EEC 7111	**PROJECT WORK**	**L**	**T**	**P**	**C**
	PHASE - I (SEMESTER III)	**0**	**0**	**12**	**6***
	PHASE - II (SEMESTER IV)	**0**	**0**	**36**	**18+6***

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

OBJECTIVES:

- To enable a student to do an individual project work which may involve design, modelling, simulation and/or fabrication.
- To analyze a problem both theoretically and practically.
- To motivate the students to involve in research activities leading to innovative solutions for industrial and societal problems.

COURSE DESCRIPTION:

Project work shall be carried out by each and every individual student under the supervision of a faculty of this department. A student may however, in certain cases, be permitted to work for the project in association with other departments or in an Industrial/Research Organization, on the recommendation of the Head of the Department. In such cases, the project work shall be jointly supervised by a faculty of the Department and the faculty of the other department of the University or an Engineer / Scientist from the organization. The student shall meet the faculty periodically and attend the periodic reviews for evaluating the progress.

Project work will be carried out in two phases, Phase-I during the pre-final semester and Phase-2 during the final semester. Phase-I shall be pursued for a minimum of 12 periods per week and Phase - II in 36 periods per week. Credits for Phase I will be accounted along with Phase II in the final semester.

In each phase, there will be three reviews for continuous assessment and one final review and viva voce at the end of the semesters. The Project Report prepared according to approved guidelines and duly signed by the supervisor(s) and the Head of the Department shall be submitted to the department.

OUTCOMES:

At the end of the course, the student will be able to

- Comprehend a problem thoroughly and provide an appropriate solution.
- Do a systematic literature survey.
- Derive a mathematical model for the system under study.
- Get proficiency over the software used for simulation and analysis.
- Present the findings of a research work in conferences and publish in journals.
- Identify and provide solution for the industrial and societal problems.

LIST OF ELECTIVES

EECY004	POWER QUALITY	L	T	P	C
		3	0	0	3

OBJECTIVES:

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

MODULE I INTRODUCTION 06

Power Quality – Significance of power quality, Terms and Definitions (IEC Standards) – Transients, Voltage Imbalance, Waveform distortion, Power frequency variations, DC offset, Electric Noise, Voltage Fluctuation and Flicker Sources of Sags and Interruptions, Estimating Voltage Sag Performance - Solutions at the End-User Level.

MODULE II DISCRETE FREQUENCY DOMAIN ANALYSIS 08

Harmonics versus Transients -Harmonic Indexes -Harmonic Sources from Commercial Loads -Harmonic Sources from Industrial Loads - Time domain methods and Frequency domain methods: Laplace's, Fourier and Hartley transform – The Walsh Transform – Wavelet Transform- Harmonic Distortion - Voltage versus Current Distortion - Locating Harmonic Sources -System Response Characteristics -Effects of Harmonic

MODULE III FUNDAMENTALS OF HARMONICS 07

Harmonic Distortion Evaluations – End users, utility -Principles for Controlling Harmonics- Where to Control Harmonics - Harmonic Studies – Computer tools for harmonic analysis- Harmonic analyzer - Devices for Controlling Harmonic Distortion -Harmonic Filter Design

MODULE IV DISTRIBUTED GENERATION AND POWER QUALITY 08

Resurgence of DG-DG Technologies – Interfacing DG to the Utility System -Power Quality Issues - Operating Conflicts - DG on Distribution Networks - Sitting DG Distributed Generation - Interconnection Standards (IEC)

MODULE V POWER QUALITY MONITORING AND ANALYSIS 08

Monitoring considerations: Power line disturbance analyzer, power quality measurement equipment, harmonic / spectrum analyzer, flicker meters, disturbance analyzer. Analysis of power outages, Analysis of unbalance: Symmetrical components of phasor quantities, Instantaneous symmetrical components, Instantaneous real and reactive powers, Analysis of distortion: On–line extraction of fundamental sequence components from measured samples

MODULE VI GROUNDING 08

Impact of grounding on power quality- Terms and definitions, Reasons for grounding, problems associated with grounding- Problems with conductors and Connectors, Missing safety ground, Multiple neutral-to-ground connections, additional ground rods, ground loops

Solutions to wiring and grounding- Proper grounding practices, Ground electrode (rod), Service entrance connections, Panel board, Isolated ground, Separately derived systems, Grounding techniques for signal Reference, grounding for sensitive equipment

Total Hours: 45

REFERENCES:

1. G.T.Heydt, "Electric Power Quality", Stars in a Circle Publications, (2nd edition) 1994.
2. Arindam Ghosh, “Power Quality Enhancement Using Custom Power Devices”, Kluwer Academic Publishers, 2002.
3. R.C. Duggan,” Power Quality “McGraw-Hill, 2003.
4. Arrillaga, j.. Bradley. D.a.. And bodger, P.S.,“Power system harmonics”, Wiley, 1985.
5. Derek A. Paice, “Power electronic converter harmonics: Calculations and multipulse methods”, Paice and Associates -1994.
6. Andreas Eberhard, “Power Quality”, Published by InTech, March 2011.
7. Surajit Chattopadhyay, Madhuchhanda Mitra,Samarjit Sengupta, “Electric Power Quality”, Springer, 2010.

OUTCOMES:

At the end of the course, the student is expected to possess knowledge and achieve skills on the following:

- Understand the power quality issues and its importance
- Evaluate the characteristics of power quality disturbances
- Know the power quality issues caused due to the insertion of DG
- Able to monitor the power quality parameters
- Identify the techniques to mitigate power quality disturbances
- Know the importance of grounding to improve power quality

EECY006	ADVANCED DIGITAL SIGNAL PROCESSING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- Provide the student with a broad, yet strong background in the traditional topics associated with processing of deterministic digital signals, e.g., discrete-time transforms, and linear filtering.
- Provide student with a strong background in traditional topics associated with processing of stochastic signals, e.g., spectrum estimation and linear prediction.
- To understand different types of prediction and filtering methods
- Introduce the student to some of the more recent developments that promise to have a broad impact on digital signal processing, e.g., nonlinear filtering and adaptive filtering.

MODULE I DISCRETE RANDOM SIGNAL PROCESSING 08

Discrete Random Processes - Ensemble Averages, Stationary processes, Bias and Estimation, Autocovariance, Autocorrelation, Parseval's theorem, Wiener-Khintchine relation, White noise, Power Spectral Density, Spectral factorization, Filtering Random Processes, Special types of Random Processes – ARMA, AR, MA – Yule-Walker equations.

MODULE II SPECTRAL ESTIMATION 08

Estimation of spectra from finite duration signals, Nonparametric methods - Periodogram, Modified periodogram, Bartlett, Welch and Blackman-Tukey methods, Parametric methods – ARMA, AR and MA model based spectral estimation, Solution using Levinson-Durbin algorithm.

MODULE III LINEAR ESTIMATION AND PREDICTION 08

Linear prediction – Forward and Backward prediction, Solution of Prony's normal equations, Least mean-squared error criterion, Wiener filter for filtering and prediction, FIR and IIR Wiener filters, Discrete Kalman filter

MODULE IV ADAPTIVE FILTERS 07

FIR adaptive filters – adaptive filter based on steepest descent method- Widrow-Hopf LMS algorithm, Normalized LMS algorithm, Adaptive channel equalization, Adaptive echo cancellation, Adaptive noise cancellation, RLS adaptive algorithm.

MODULE V MULTIRATE DIGITAL SIGNAL PROCESSING 08

Mathematical description of change of sampling rate – Interpolation and Decimation, Decimation by an integer factor, Interpolation by an integer factor, Sampling rate conversion by a rational factor, Polyphase filter structures, Multistage implementation of multirate system, Application to subband coding – Wavelet transform.

MODULE VI WAVELET TRANSFORM 06

Introduction to continuous discrete and fast wavelet transforms. Families of Wavelets: orthogonal and biorthogonal wavelets, Daubechies' family of wavelets in detail.

Total Hours: 45

REFERENCES:

1. Monson H. Hayes, 'Statistical Digital Signal Processing and Modeling", John Wiley and Sons, Inc, Singapore, 2002
2. John J. Proakis, Dimitris G. Manolakis, : Digital Signal Processing', Pearson Education, 2002
3. Rafael C. Gonzalez, Richard E. Woods, " Digital Image Processing", Pearson Education Inc.,Second Edition, 2004 (For Wavelet Transform Topic)

OUTCOMES:

- Have a more thorough understanding of the relationship between time and frequency domain interpretations and implementations of signal processing algorithms;
- Understand and be able to implement adaptive signal processing algorithms based on second order statistics;
- Students will have the ability to solve various types of practical problems in DSP
- Be familiar with some of the most important advanced signal processing techniques,
- understand the multi-rate processing wavelet transform and time-frequency analysis techniques to solve real time process.
- Apply the above tools to real-world problems including spectral analysis, filter design, noise cancellation, signal compression, rate conversion, feature extraction, inverse problems.

EECY011	HIGH VOLTAGE DIRECT CURRENT TRANSMISSION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To identify situations where HVDC is a better alternative
- To acquire knowledge of HVDC converters, system control and development of MTDC systems
- To perform power flow analysis in an integrated EHVAC - HVDC system.

MODULE I COMPARISON OF EHVAC AND HVDC SYSTEMS 07

Technical and economic problems in bulk power transmission over long distances using EHV / UHV AC lines - HVDC alternatives for transmission - Description of HVDC systems - its application - comparison of EHVAC and HVDC systems.

MODULE II ANALYSIS OF HVDC CONVERTERS 08

Planning of HVDC transmission - modern trends in HVDC transmission – DC breakers - U/G cable transmission - VSC based HVDC - pulse number – choice of converter configuration - simplified analysis of Graetz circuit - 6 pulse converter bridge characteristics - generation of harmonics and filtering.

MODULE III ANALYSIS AND CONTROL OF HVDC SYSTEMS 08

Twelve pulse converter characteristics - its advantages - detailed analysis of Converters - Principles of DC link control - converter / inverter control characteristics - system control hierarchy - firing angle control - current and extinction angle control - power control - higher level controllers.

MODULE IV MULTI TERMINAL HVDC SYSTEMS 07

Introduction to MTDC systems – potential applications of MTDC systems – Types of MTDC systems – Control and protection of MTDC systems – Detailed study about developments of MTDC systems.

MODULE V POWER FLOW ANALYSIS 08

Per unit system for DC quantities – modeling of DC links – solution of DC power flow – solution of AC – DC power flow – case studies

MODULE VI SIMULATION 07

System simulation – philosophy and tools – HVDC systems simulation: modeling of HVDC systems for digital simulation – dynamic interaction between DC and AC systems. Application in Wind Power generation.

Total Hours: 45

REFERENCES:

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

OUTCOMES:

At the end of the course, the student is expected to possess knowledge and achieve skills on the following:

- Identification of situations where HVDC transmission is a better alternative to EHVAC transmission
- The operation and control of converter/Inverter for power control
- The development and applications of MTDC systems
- Power flow analysis used for Integrated EHVAC-HVDC system
- Steady state performance simulation and analysis
- Analysis of HVDC controllers.

EECY012 WIND ENERGY CONVERSION SYSTEM

L	T	P	C
3	0	0	3

OBJECTIVES:

- To understand the demand for electrical power generation from the renewable wind and fundamentals of wind power.
- To study and understand about the wind turbine components, power generation machinery, and its control systems.
- To simulate the wind turbine dynamic behavior when integrated to grid and in standalone operation.

MODULE I INTRODUCTION 08

Introduction-Historical Development and current status of Wind power-Generators and Power Electronics for wind turbines - Power System Impacts of Wind turbines-Wind speed estimation-wind speed measurements-Rayleigh distribution-Maximum Power obtainable-Bertz limit-Power coefficient –aerodynamics of Wind rotor-Blade element theory-aerodynamic efficiency-Wind energy Conversion System Components.

MODULE II WIND TURBINE 08

Types of Wind Turbine-Rotor design consideration-Tip speed ratio-blade profile-Power regulation-Yaw control –Pitch angle control-stall control-schemes for maximum power extraction.

MODULE III FIXED SPEED AND VARIABLE SPEED SYSTEMS 08

Fixed speed and variable speed wind turbine- Need of variable speed systems-Power-wind speed characteristics-Generation schemes with fixed and variable speed turbines-Comparison of different schemes.

MODULE IV MODELING AND SIMULATION OF FIXED SPEED AND VARIABLE SPEED WIND GENERATORS 08

Modeling of Fixed speed Induction generator-axes transformation-flux linkage equations-voltage equations-state equations-modeling of variable speed DFIG for Wind Energy Conversion Systems-Converter Control System- transient stability simulation of fixed speed induction generator using EUROSTAG 4.3-Doubly Fed Induction Generator(DFIG) modeling - controller modelling -modelling of DFIG in EUROSTAG - transient stability simulation of powersystems with induction generators using EUROSTAG 4.3.

MODULE V POWER ELECTRONICS IN WIND ENERGY CONVERSION SYSTEM 08

Induction generator-Controlled firing angle scheme with AC and DC side Capacitor-Scalar method-flux vector scheme-Control scheme for Synchronous generator with variable speed drive-Variable speed synchronous generator control with boost converter

MODULE VI GRID CONNECTED SYSTEMS 05

Stand alone and Grid Connected WECS system-Grid connection Issues- Impacts of wind power on Power System Stability-wind plant reactive power capability and its requirements-voltage Control and active power control -Storage technologies.

Total Hours: 45

REFERENCES:

1. S.N.Bhadra, D.Kasthra,S.Banerjee, “Wind Electrical Systems”,OxfordHigherEduction, 2005.
2. Thomas Ackermann,”Wind Power in Power system”,Wiley 2012.
3. L.L.Freris ,"Wind Energy conversion Systems", Prentice Hall, 1990.
4. Jian Zhang, Adam Dysko, John O'Reilly, William E. Leithead," Modeling andperformance of fixed-speed induction generators in power system oscillationstability studies", Electric Power System Research Vol. 78,pp: 1416-1424,2008.
5. Andre´s Feijoo, Jose Cidras, Camilo Carrillo, "A third order model for thedoubly-fed induction machine", Electric Power Systems Research 56 (2000)121-127.
6. Eurostag 4.3 Theory Manual Part I.
7. Ion Boldea, "Variable speed generators", Taylor & Francis group, 2006.
8. E.W.Golding, "The generation of Electricity by wind power", Redwood burn Ltd., Trowbridge, 1976.
9. S.Heir, "Grid Integration of WECS", Wiley 1998.

OUTCOMES:

At the end of the course, the student will be able to:

- Recognize the need of renewable energy technologies and their role in the world energy demand.
- Identify and mathematically model the wind turbine components, calculate the available wind power, predict mechanical loads based on design, and discuss the generation of electrical power.

- To numerically simulate the wind turbine dynamic system behavior with integration of component, and control for given real time application.
- Mathematically model and simulate the transient and steady state performance of the stand-alone and grid connected wind generators using EUROSTAGE, MATLAB, CYME packages.
- Analyze the wind power integration issues and their mitigation techniques.
- Identify the present and the future energy storage technologies used for standalone operation and grid connected operation .

EEC 015 FLEXIBLE A.C. TRANSMISSION SYSTEMS

L	T	P	C
3	0	0	3

OBJECTIVES:

- To introduce students to the transmission challenges of modern electrical power systems
- To present the basic concepts, principles and operation of fast high power electronic controllers known as Flexible AC Transmission Systems (FACTS)
- To provide advanced knowledge and understanding of power electronics applications in power transmission systems
- To introduce the operating principles, control systems and modelling of different FACTS devices (SVC, SSSC, SR, TCSC, STATCOM, UPFC, IPFC, etc.)
- To understand the influence of measurement systems, network resonances and harmonic interactions on the performance of FACTS control systems
- To provide the techniques of FACTS controller design for enhancing power transfer, stability and damping, mitigating sub-synchronous resonances, preventing voltage instability, etc.
- To understand the interactions amongst various FACTS Controllers and techniques for their coordination and placement

MODULE I INTRODUCTION 08

Reactive power - uncompensated transmission lines - load compensation - system compensation - lossless distributed parameter lines -symmetrical lines - midpoint conditions of a symmetrical line case study passive compensation - shunt compensation -series compensation - effect on power-transfer capacity.

MODULE II STATIC VAR COMPENSATOR (SVC) 08

Voltage control by SVC - advantages of slope in dynamic characteristics - influence of svc on system voltage - design of SVC voltage regulator - modelling of SVC for power flow and transient stability.

MODULE III THYRISTOR CONTROLLED SERIES CAPACITOR (TCSC) 07

Operation of the TCSC - different modes of operation - modelling of TCSC - variable reactance model - modeling for power flow and stability studies. sub synchronous resonance- torsional interaction,- torsional torque - NGH damping schemes.

MODULE IV VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS 7

Static synchronous compensator (STATCOM) - principle of operation - V-I characteristics. SSSC-operation of SSSC and the control of power flow - modeling of SSSC in load flow and transient stability studies -UPFC and IPFC.

MODULE V CO-ORDINATION OF FACTS CONTROLLERS 07

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

MODULE VI APPLICATIONS OF FACTS CONTROLLERS 08

Applications of SVC - enhancement of transient stability - steady state power transfer - enhancement of power system damping - prevention of voltage instability. -applications of TCSC- improvement of the system stability limit - enhancement of system damping. applications of STATCOM- steady state power transfer- enhancement of transient stability - prevention of voltage instability - applications of SSSC – SSR mitigation.

Total Hours: 45

REFERENCES:

- R.Mohan Mathur, Rajiv K.Varma, “Thyristor - Based FACTS Controllers for Electrical Transmission Systems”, IEEE press and John Wiley & Sons, Inc., 2002.
- Narain G. Hingorani, “Understanding FACTS -Concepts and Technology of Flexible AC Transmission Systems”, Standard Publishers Distributors, Delhi- 110 006,1999.
- K.R.Padiyar, “FACTS Controllers in Power Transmission and Distribution”, New Age International (P) Limited, Publishers, New Delhi, 2008 .
- A.T.John, “Flexible A.C. Transmission Systems”, Institution of Electrical and Electronic Engineers (IEEE)”, Wiley IEEE Press,1999.
- V.K.Sood, “HVDC and FACTS controllers - Applications of Static Converters in Power System”, Kluwer Academic Publishers, 2004.

OUTCOMES:

At the end of the course, the student is expected to possess knowledge and achieve skills on the following:

- Identify the needs of power systems and utility networks where installation of FACTS Controllers/Devices becomes essential
- Compute power transmission capability of a transmission system and apply reactive compensation methods for its improvement
- Comprehend the operating principles, control systems and modeling of different FACTS Controllers
- Understand the influence of measurement systems, network resonances and harmonic interactions on the performance of FACTS control systems
- Apply the techniques of FACTS controller design for enhancing power transfer, increasing stability, augmenting system damping, mitigating sub-synchronous resonances, preventing voltage instability, performing load compensation, etc.
- Analyze the interactions amongst various FACTS Controllers

EECY018 SMART POWER GRID

L	T	P	C
3	0	0	3

OBJECTIVES :

- Introduce the fundamentals of smart grids.
- Introduce modeling of devices associated with smart grids.
- Introduce the different automation and networking standards.
- Introduce the concept of Wide area measuring systems and Phasor measurement units.(PMU)

MODULE I SMART GRID FUNDAMENTALS 09

Smart grid structure – Interactive grid – Micro grid – Distributed Resources modeling – communication infrastructure – sensing and Control devices – smart grid characteristics.

MODULE II COMPONENTS AND STANDARDS 09

Smart grid components – Metering – Virtual power plants- Benefits and cost elements – Pricing regulations – Networking Standards and integration – Analytics.

MODULE III AUTOMATION TECHNOLOGIES 09

Control centre systems – Data management principles – Smart Grid implementation standards and procedure – Advanced Metering Infrastructure – Outage management – Distribution and Substation automation .

MODULE IV WIDE AREA MEASUREMENT SYSTEMS AND PMU 06

Wide area measurement systems –Phasor Measurement Units- Optimal placement algorithm for PMUs. Smart grid experimentation plan for load forecasting.

MODULE V CASE STUDY I 06

Smart meters – Cloud computing and security issues - Forecasting – Coordination between cloud computing and Smart power grids – Development of power system models and control and communication software.

MODULE VI RECENT TRENDS IN SMART POWER GRIDS 06

Demand Response – concepts and models.Real time pricing models for practical applications-SCADA in smart grids.

Total Hours: 45

REFERENCES :

1. Ali Keyhani :" Design of Smart Power Grid Renewable Energy Systems ", First Edition , John Wiley Inc., 2011
2. Tony Flick and Justin Morehouse : "Securing the Smart Grid – Next generation Power Grid security ", Elsevier Publications,2011.
3. Krzysztof Iniewski:Smart Grid Infrastructure and Networking , 1st Edition , 2012.
4. Stephen F Bush :Smart Grid Communication – Enabled Intelligence for Electric Power Grid, Wiley IEEE .,2014
5. James Momoh : Smart Grids , Fundamentals of Design and Analysis .,2014.
6. Mini . S. Thomas :Power System SCADA and Smart Grids.
7. Kenneth . C.Budka , Jayant G.Deshpande :Communication Networks for Smart Grids:Making Smart Grid Real , 2014

OUTCOMES:

At the end of the course the student is expected to possess knowledge and skills on the following :

- Ability to design and implement Smart Power Grid Power Systems
- Ability to apply the concept of demand response in Smart grids.
- Ability to apply Smart grid concepts to real applications.
- Ability to co ordinate between cloud computing and smart grids
- Ability to apply SCADA in smart power grids
- Ability to use PMUs for optimal placement in smart grids.

EECY019	DISTRIBUTED GENERATION AND MICROGRID	L	T	P	C
		3	0	0	3

Course Objectives:

- To impart the importance of renewable based generation system to meet the growing demands
- To locate distributed generation system optimally in the distribution system network and to study its impacts

MODULE I INTRODUCTION 08

Microgrid basic concepts – architecture - operational conditions, Microgrid : merits and demerits - functionalities and variables in microgrid - issues in microgrid. Types of microgrid (LV microgrid, MV microgrid - DC microgrid, AC microgrid, hybrid) - Microgrid as part of smarter grid Modes of operation : grid connected mode - islanded mode - transition between grid connected mode and islanded mode.primary control strategy - secondary control strategy - Control of distribution generation - demand side management - Opportunities and risk of different market players

MODULE II DISTRIBUTED ENERGY RESOURCES AND STORAGE DEVICES 08

Distributed Energy Resources: solar – wind – CHP – MCHP – Microturbine - Diesel generators –geo thermal –working, characteristics and mathematical modeling, Storage devices-Batteries - fuel cells - super capacitors.

MODULE III DISTRIBUTED SYSTEM EXPANSION 08

Power flow, Short circuit and loss calculations- with and without distributed generation- Distribution system reliability analysis –Distribution system expansion planning – load characteristics – load forecasting – design concepts – optimal location of distributed generation – solution technique.

MODULE IV CONTROLLERS 08

Three phase converter - Three phase Voltage source Inverter (VSI) – Boost Converter – PWM Techniques - P-Q Control - Structure of the VSI PQ Controller - Power-Voltage (PV) Control Scheme - Frequency (Vf) Control Scheme - generation Control Based on Droop Concept - adaptive droop control, Phase locked loop for synchronization.

MODULE V PROTECTION ISSUES 07

Requirements of protection - issues in protection (LOM, Blinding of protection, unwanted islanding, lack of selectivity, failure of co-ordination between fuse and recloser) - challenges in protection scheme – Solutions for microgrid protection - digital relays- Adaptive protection scheme : centralized, decentralized–Multiagent based protection scheme – protection scheme based on variables

MODULE VI MICROGRID COMPONENTS 06

PMU basic concepts - International Electrotechnical Commission (IEC) 61850, 61850-7-420, 61850-8. Renewable Microgrid controller RMC 600. Microgrid pilots : KERI – CERTS - Intelligent Electronic Device (IED) - Microgrid Management system (MMS) - Static Transfer switch (STS) - RTU/ gateway - Smart metering – Sensing Devices.

Total Hours: 45

REFERENCES:

1. Jukka Ihamäki, **"Integration of microgrids into electricity distribution networks"** Master's Thesis in Lappeenranta University of Technology, 2012, pages-105
2. Amirhossein Hajimiragha, "**Generation Control in Small Isolated Power Systems"** Master of Science Thesis -Royal Institute of Technology, Department of Electrical Engineering Stockholm 2005.
3. *Juan Carlos V´asquez Quintero, "*Decentralized Control Techniques Applied to Electric Power Distributed Generation in Microgrids *dissertation submitted for the degree of European Doctor of Philosophy,* June 10, 2009.
4. *Stanley H.Horowitz and Arun G. Phadke, " Power System Relaying third edition, John Wiley & sons*
5. Renewable Microgrid controller RMC 600 – ABB Brochure
6. Taha Selim Ustun, Cagil Ozansoy and Aladin Zayegh, " Fault current coefficient and time delay assignment for microgrid protection system with central protection unit" IEEE Transaction (accepted for publication in future issue of the journal-DOI-10.1109/TPWRS.2012.2214489
7. Taha Selim Ustun, Cagil Ozansoy and Aladin Zayegh, " Modelling of a centralized Microgrid Protection system and Distributed Energy Resources according to IEC 61850-7-420" IEEE Transaction on power systems, vol 27, No.3, pp 1560-1567, 2012.
8. M. Amin Zamani, Amirnaser Yazdani, and Tarlochan S. , "A Communication-Assisted Protection Strategy for Inverter-Based Medium-

Voltage Microgrids", IEEE Transactions on Smart Grid, Vol. 3, No. 4,pp.2088-2099, 2012

9. Eric Sorotomme, S.S. Venkata, Joydeep Mitra, " Microgrid protection using communication assisted digital relays" IEEE transaction on power delivery, vol.25, No.4, pp.2789-2796, 2010

OUTCOMES:

At the end of the course, the student will be able to

- Know the basic concepts with respect to microgrid
- Model the distributed generator for distribution network
- Optimally locate the distributed generator in the distribution system
- Address the Issues involved in microgrid protection
- Model controllers for distributed generator to interface it to the distribution system network

EECY041 DIGITAL SIGNAL PROCESSORS

L	T	P	C
3	0	0	3

OBJECTIVES:

- To impart knowledge on the architectural details and instruction set of TMS320F2812 processor.
- To provide practical experience with Digital Signal Processors.
- Introduces Code Composer Studio IDE for C 2000 Processors.
- To implement DSP Processor in real time Digital Motor Control application.

MODULE I ARCHITECTURE OF F2812 06

TMS320F2812 Architecture - The F2812 CPU-F2812 Math Units-Data Memory Access -Internal Bus Structure- Atomic Arithmetic Logic Unit (ALU) -Instruction Pipeline - Memory Map - Code Security Module - Interrupt Response- Operating Modes - Reset Behaviour.

MODULE II PROGRAM DEVELOPMENT TOOLS 08

Code Composer Studio IDE - The Software Flow - Code Composer Studio – Basics - Lab Hardware Setup - Code Composer Studio – Step by Step procedure - Create a project - Setup Build Options Linker Command File - Download code into DSP - beginner's project - Objective Procedure - Open Files, Create Project File- C28x Flash Programming - C28x Start-up Sequences -C28x Flash Memory Sectors Flash Flash Configuration Registers - Flash Programming Procedure .

MODULE III DIGITAL I/O 07

Data Memory Mapped Peripherals - The Peripheral Frames - Unit Digital I/O Registers Module - Watchdog Timer - System Control and Status Register - Low Power Mode – Digital Input / Output programmes.

MODULE IV INTERRUPT SYSTEM 08

C28x Core Interrupt Lines - The C28x RESET - Reset Bootloader - Interrupt Sources - Maskable Interrupt Processing - Peripheral Interrupt Expansion - C28x CPU Timers - Serial Peripheral Interface (SPI) Data Transfer - SPI Registers - SPI communication.

MODULE V C28X EVENT MANAGER AND C28X ANALOGUE DIGITAL CONVERTER 08

Event Manager Block Diagram - General Purpose Timer Timer Operating Modes - Interrupt Sources - GP Timer Registers - GP Timer Interrupts - Event Manager

Compare Units Capture Units - Quadrature Encoder Pulse Unit (QEP).- Generate a PWM sine wave -.ADC Module Overview - ADC in Cascaded Mode -ADC in Dual Sequencer Mode - ADC Register Block .

MODULE VI DIGITAL MOTOR CONTROL APPLICATIONS 08

C28x IQ – Math Library - IQ – Math Library Functions - IQ- Math Application- FOC -C28x FIR – Filter - Texas Instruments C28x Filter Library - C28x Digital Motor Control - Field Orientated Control (FOC) Core Math Operations - PARK Transform - CLARKE Transform - Texas Instruments Digital Motor Control Library Modules . FOC for PMSM - Hardware Laboratory Setup - PMSM control project – Build levels.

Total Hours: 45

REFERENCES:

1. Code Composer Studio User's Guide Literature Number: SPRU328 February 2000, Copyright © 1999-2000, Texas Instruments Incorporated.
2. TMS320F2810, TMS320F2811, TMS320F2812, TMS320C2810, TMS320C2811, TMS320C2812 Digital Signal Processors Data Manual, Copyright © 2001–2012, Texas instrument Incorporated.
3. TMS320F2812 DIGITAL SIGNAL PROCESSOR IMPLEMENTATION TUTORIAL – Texas instruments.
4. B. B. Venkatramani & M.Bhaskar, " Digital Signal Procesors architecture, Programming and applications, Tata McGraw Hill 2002.
5. TMS320F/C24/X DSP controllers, Refernce guide literature No : SPRU 160c, June 1994.

OUTCOMES:

At the end of the course, the student is expected to possess knowledge and achieve skills on the following:

- Programming Knowledge in DSP and its real time application.
- To configure DSPBIOS to handle hardware interrupts (HWI)
- Implementing Digital Motor Control Library Modules.
- Computing steps necessary to build a control scheme for Field Oriented Control (FOC).
- Board level operations of the Digital Signal Processors (DSP)based on the Texas Instruments TMS320F2812 Processor.

EECY042 ROBOTICS AND FACTORY AUTOMATION

L	T	P	C
3	0	0	3

OBJECTIVES :

- To identify the basic component of manufacturing automation and categorize the different types of automated production Process.
- To understand how knowledge based system technology can improve manufacturing enterprises, to design elementary Mechanisms for automation.
- To understand the principle of industrial sensors.
- To understand the working of Robots.

MODULE I FUNDAMENTAL CONCEPTS OF ROBOTICS 07

History, Present status and future trends in Robotics and automation-Laws of Robotics-Robot definitions –Robot anatomy Specification of Robots-resolution, repeatability and accuracy of a manipulator – Robotics applications.

MODULE II ROBOT DRIVES AND POWER TRANSMISSION SYSTEMS 08

Robot drive mechanisms, hydraulic, electric servomotor, stepper Motor, pneumatic drives-Mechanical transmission method, Gear Transmission, Belt drives, cables, Roller chains, Link-Rod systems- Rotary to Rotary motion conversion, Rotary to Rotary motion conversion, Rotary to Linear motion conversion, Rack and Pinion Drives, Lead screws, Ball Bearing screws, End effectors, Types.

MODULE III SENSORS 08

Sensor characteristics , Position sensors, Potientiometers, Encoders, Resolvers, LVDT, Velocity sensors, Tachogenerators - Encoders-Proximity sensors, Limit switches, Tactile sensors - Touch sensors – Force and torque sensors.

MODULE IV VISION SYSTEMS FOR ROBOTICS 08

Robot vision systems, Image capture-cameras, vision and solid State Image representation- Gray scale and colour images, image sampling and quantization-Image processing and analysis – Image Data reduction- Segmentation – Feature extraction – Object Recognition – Image capturing and communication – JPEG,MPEG And H.26x standards, packet video, error concealment – Image Texture analysis.

MODULE V PLC 08

Building blocks of automation , Controllers, PLC – Role of PLC in FA – Architecture of PLC – Advantages – Types of PLC – Types of Programming – Simple process control programs using Relay Ladder Logic and Boolean logic – PLC arithmetic functions.

MODULE VI FACTORY AUTOMATION 06

Flexible Manufacturing Systems concept – Automatic feeding Lines, ASRS, Lines, automatic inspection – Computer Integrated Manufacture – CNC, intelligent automation. Industrial networking, Bus standards, HMI systems, DCS and SCADA , Wireless controls.

Total Hours: 45

REFERENCES :

1. Richard D. Klafter, Thomas .A.Chmielewski, Michael Negin,“Robotics Engineering Integrated Approach”,Eastern Economy Edition , PHI , 1989
2. Fu K.S., Gonzalez R.C., Lee C.S.G, “Robotics:Control ,Sensing, Vision and Intelligence “McGraw Hill Book Company , 1987. Mikell P Groover et al ., “Industial Robots – Technology , Programming and applications”McGraw Hill , New York, 1986.
3. Saeed B Niku ,”Introduction to Robotics Analysis , Systems, Applications Prentice Hall of India Pvt. Ltd New Delhi , 2003.
4. Deb S.R. , “Robotics Technology and Flexible Automation “, Tata McGraw Hill Publishing Company Ltd., 1994.
5. Jegannathan .R, “Introduction to Robotics”, 2004.

OUTCOMES:

At the end of the course the student is expected to possess knowledge and skills on the following :

- Ability to design a Robot.
- Ability to troubleshoot Factory Automation products.
- Ability to master PLC programming and applications.
- Ability to apply Robotic concepts in Industrial systems.

EECY043 SCADA AND DCS

L	T	P	C
3	0	0	3

OBJECTIVES:

- The aim of this course is to give an in depth study of SCADA and PLC.
- To acquire knowledge of application of software automation blocks and DCS.
- To expose the students to the Micro SCADA techniques

MODULE I INTRODUCTION 06

Introduction to automation tools PLC, DCS, SCADA, Hybrid DCS/PLC.

MODULE II DCS PROJECT 08

Development of User Requirement Specifications - Functional Design Specifications for automation tool - GAMP, FDA.

MODULE III PROGRAMMABLE LOGIC CONTROLLERS 08

Introduction of Advanced PLC programming, Selection of processor, Input/ output MODULEs - Interfacing of Input/output devices, Operator Interface - OPC- study of SCADA software - Interfacing of PLC with SCADA software.

MODULE IV DCS 09

Introduction to architecture of different makes - DCS Specifications, configuration of DCS blocks for different applications - Interfacing of protocol based sensors - Actuators and PLC systems, Plant wide database management- Security and user access management - MES, ERP Interface.

MODULE V STUDY OF ADVANCE PROCESS CONTROL BLOCKS 09

Statistical Process Control - Model Predictive Control - Fuzzy Logic Based Control - Neural-Network Based Control Higher Level Operations: Control & Instrumentation for process optimization - Applications of the above techniques to the same standard units/processes.

MODULE VI MICRO SCADA FOR POWER ELECTRONIC SYSTEMS 05

System concept –Hardware: Base computer - Workstations-Front ends-Peripherals Software Programming-Process Objects – Command Procedures – RTU Integration –Communication to Third Party Systems –Functional description: process pictures- operation-Alarm handling-Event Handling- reports- Trends

Total Hours: 45

REFERENCES:

1. Gary Dunning, “Introduction to Programmable logic Controllers”, Delmar Thomson learning, 2001.
2. Webb & Reis, “Programmable logic Controllers”, (Prentice Hall), 2003.
3. Jose A. Romagnoli, Ahmet Palazoglu, 'Introduction to process Control' (CRC Taylor and Francis group), 2013.
4. “Statistical Process Control” -ISA Handbook.
5. B.G. Liptak “Handbook of Instrumentation- Process Control”.
6. Installation and user manuals of different DCS, PLC Vendors, 2004.

OUTCOMES:

At the end of the course, the student is expected to possess knowledge and achieve skills on the following:

- Basics of SCADA & DCS.
- Appropriate knowledge and skills in Industrial automation systems with the use of DCS, PLCs, and SCADA.
- An ability to apply creativity in design of systems, components or processes appropriate to power electronic circuits.
- Ability to get a grip on micro scada for power electronics applications
- Ability to perform programming in SCADA and DCS.

EECY044 SPACECRAFT POWER SYSTEMS

L	T	P	C
3	0	0	3

OBJECTIVES:

- To provide covers the entire scope of spacecraft power systems.
- To study and analyze the power conditioning, energy management and the operational
- aspects of spacecraft power systems
- To study and understand the Satellite overview, space environment and its effects.
- To understand the power electronics and magnetics, distribution harness, protection, and ancillary components of the spacecraft.

MODULE I SATELLITE OVERVIEW 07

Satellite systems - Earth orbit classification–Orbit mechanics-Satellite stabilization methods- Near-Earth Space Environment - Power System Options- Environmental Effects. Solar Array– I–V and P–V characteristics - Array construction – Array performance- Array design- Advances in PV technology - Concentrator array- Battery: Types of batteries - Properties and performance

MODULE II POWER ELECTRONICS 08

Switching devices - Shunt regulator - Linear and PWM shunts – Shunt circuit design - Bus ripple filter design - Power converters - Battery charge converter - Battery discharge converter - Load power converter - Voltage and current regulators

MODULE III ENERGY BALANCE AND POWER MANAGEMENT 08

Energy balance analysis - Energy balance simulation runs - Dynamic Performance and Stability - Electromagnetic Interference and Compatibility - Electrostatic Discharge.

MODULE IV DISTRIBUTION HARNESS, PROTECTION AND ANCILLARY COMPONENTS 06

Ampacity of wires - R-C-L parameters - Conductor materials - Wire insulation and cable shield- Harness mass minimization-Fuse protection Remote power controllers - Early fault detection - Solar array drive -Deployment devices – Relays - Battery let-down unit - Radiation shield - EMI shield

MODULE V SPECIAL POWER SYSTEMS 08

Interplanetary and Deep Space Missions–Radioisotope Thermoelectric Generator (RTG) - High-Power High-Voltage Systems: High-voltage PV array- High-power nuclear TEC - High-voltage design issues - High-voltage direct current - High-frequency alternating current - High-power components - Very-high-voltage system - Repetitive pulse power - Multi-megawatt burst-power.

MODULE VI ELECTRIC PROPULSION 08

Types of electric propulsion– Solar PV propulsion -Solar thermal propulsion Nuclear power propulsion -Microwave beam propulsion - Tether power propulsion-Fuel Cell Power - Flywheel Energy Storage - Superconductors in Space - Microwave Beam Power Satellite.

Total Hours: 45

REFERENCES:

1. Mukund R. Patel, Modern SPACECRAFT POWER © 2005 by CRC Press LLC.
2. Grechnev, A.B. et al. Centralized power as basis of new philosophy of space power engineering, in Proceedings of the 34th Intersociety Energy, Conversion Engineering Conference, SAE, 1999, Paper No. 2436.
3. SAIC and Futron Corporation, Space Solar Power Concept Definition Study,NASA Report No. SAIC-99/1016, February 1999.
4. Mankins, J.C. and Howell, J., Overview of the space solar power exploratory research and technology program, in Proceedings of the 35th Intersociety Energy Conversion Engineering Conference, AIAA, 2000, Paper No. 3060.

OUTCOMES:

At the end of the course, the student is expected to possess knowledge and achieve skills on the following:

- Abilty to design a closed loop control of AC and DC drives
- Ability to analyze the new developments Spacecraft power systems.
- Ability to maintain a leading edge in designing and operating a variety of Spacecraft power systems.
- This course allows the students to the knowledge Special systems such as interplanetary and deep space.
- The students is expected to become a professional in Energy management.

EECY045	MODERN ELECTRIC, HYBRID ELECTRIC AND FUEL CELL VEHICLES	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the dynamics of a motor-load Vehicles.
- To study the Configurations and Performance of Electric, Hybrid Electric and Fuel Cell Vehicles
- To analyze the operation of modern converters for Electric Vehicles.
- To understand the Battery Technologies and Electrical breaking.

MODULE I VEHICLE FUNDAMENTALS 06

General Description of Vehicle Movement-Dynamic Equation: power converter Tire–Ground Adhesion and Maximum Tractive Effort - Power Train Tractive Effort and Vehicle Speed - Vehicle Power Plant and Transmission Characteristics-Power Plant Characteristics - Transmission Characteristics - Vehicle Performance.

MODULE II ELECTRIC AND HYBRID ELECTRIC VEHICLES 08

Configurations of Electric Vehicles– Performance of Electric Vehicles– Tractive Effort in Normal Driving- Energy Consumption- Hybrid Electric Vehicles: – Concept of Hybrid Electric Drive Trains– Architectures of Hybrid Electric Drive Trains: Series and Parallel Hybrid Electric Drive Trains.

MODULE III ELECTRIC PROPULSION SYSTEMS 08

DC Motor Drives: Multiquadrant Control of Chopper Fed DC Motor - Induction Motor Drives: Constant Volt/Hertz Control - Field Orientation Control(FOC) - Voltage Source Inverter for FOC - Permanent Magnetic Brush-Less DC Motor Drives: Control of BLDC Machines - Sensorless Techniques: Switched Reluctance Motor Drives - Sensorless Control.

MODULE IV ENERGY STORAGES 08

Electrochemical Batteries-Battery Technologies-Lead-Acid Batteries - Nickel-based Batteries– Lithium-Based Batteries- Ultracapacitors– Ultrahigh-Speed Flywheels– Hybridization of Energy Storages.

MODULE V REGENERATIVE BRAKING 08

Fundamentals of Regenerative Braking: Energy Consumption in Braking - Braking Power and Energy on Front and Rear Wheels - Brake System of EVs and HEVs - Series Brake: Optimal Feel - Optimal Energy Recovery - Parallel Brake - Antilock Brake System (ABS).

MODULE VI FUEL CELL VEHICLES 07

Operating Principles of Fuel Cells – Fuel Cell Technologies – Fuel Supply : Hydrogen Storage.- Hydrogen Production – Ammonia as Hydrogen Carrier - Nonhydrogen Fuel Cells - Fuel Cell Hybrid Electric Drive Train Design: Configuration - Control Strategy Parametric Design.

Total Hours: 45

REFERENCES:

1. Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, Ali Emad, Modern electric, hybrid electric, and fuel cell vehicles: fundamentals, theory, and design © 2005 by CRC Press LLC.
2. G.K.Dubey, Powersemiconductor controlled drives, Prentice Hall- 2000.
3. G.K.Dubey, Fundamentals of Electrical Drives, Narosa-1999.
   A. Nasar, Boldea , Electrical Drives, Second Edition, CRCPress-2006.
4. M. A. ElSharkawi , Fundamentals of Electrical Drives , Thomson Learning - 2000.
5. W. Leohnard, Control of Electric Drives,-Springer-2001.
6. Murphy and Turnbull, Power Electronic Control of AC motors, Pergamon Press, 1973.
7. Vedam Subrahmaniam, Electric Drives, TMH-2000.

OUTCOMES:

At the end of the course, the student is expected to possess knowledge and achieve skills on the following:

- Ability to analyze the vehicle power source characteristics, transmission characteristics.
- Solve equations used to describe vehicle performance.
- Able to analyze different controls of regenerative braking
- Design of electric propulsion systems and energy storage devices
- Ability to design the fuel cell system, electric propulsion, and the energy storage system.

ECY046	TRANSFORMERS AND INDUCTORS FOR POWER ELECTRONICS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the magnetic core characteristics of different core materials.
- To study design methods for converter Transformers and high frequency.
- Inductors.
- To provide real-world step-by-step design examples.
- To offer a practical approach with design examples for design engineers.

MODULE I RECTIFIER TRANSFORMER DESIGN 06

Multiphase Rectifier Circuits - Area Product, Ap, and Core Geometry, Kg, for Three-Phase Transformers - Output Power Versus Apparent, Pt, Capability - Relationship, Kg and Ap to Power Transformer Regulation - Relationship, Ap, to Transformer Power Handling Capability.

MODULE II INDUCTOR DESIGN 08

DC Inductor Design: Critical Inductance for Sine Wave Rectification - Critical Inductance for Buck Type Converters - Core Materials, Used in PWM Converters - Gapped Inductor Design- DC Inductor Design Using Powder Cores- Toroidal Powder Core - Design AC Inductor Design - Input Filter Design – Capacitor – Inductor – Oscillation - Applying Power - Resonant Charge - Input Filter Inductor Design Procedure.

MODULE III FLYBACK CONVERTER, TRANSFORMER DESIGN 08

Energy Transfer - Discontinuous Current Mode - Continuous Current Mode - Continuous and Discontinuous Boundary - The Buck Converter and Boost Converter - Continuous and Discontinuous Current Design Equations - Discontinuous Current and Continuous Current Isolated, Buck-Boost Design Equations - Designing Boost Inductors for Power Factor Correction (PFC).

MODULE IV FORWARD CONVERTER TRANSFORMER AND OUTPUT INDUCTOR DESIGN 08

Circuit Operation - Comparing the Dynamic B-H Loops - Forward Converter Waveforms - Transformer Design Using the Core Geometry, Kg, Approach Forward Converter Output Inductor Design - Output Inductor Design Using the Core Geometry, Kg, Approach.

MODULE V QUIET CONVERTER DESIGN 08

The Voltage-fed Converter - Regulating and Filtering - The Current-fed Converter - The Quiet Converter - Regulating and Filtering - Quiet Converter Waveforms - Technology on the Move - Window Utilization Factor, Ku - Temperature Stability - Calculating the Apparent Power, P,. Quiet Converter Design Equations - Transformer Design, Using the Core Geometry, Kg, Approach Winding Termination - PC Board Base Materials - Core Mounting and Assembly.

MODULE VI PLANAR TRANSFORMERS 07

Planar Transformer Basic Construction-Planar Integrated PC Board Magnetics - Core Geometries - Planar Transformer and Inductor Design Equations - Window Utilization, Ku - Current Density, J - Printed Circuit Windings - Calculating the Mean Length Turn, MLT - Winding Resistance and Dissipation - PC Winding Capacitance - Planar Inductor Design - Winding Termination - PC Board Base Materials - Core Mounting and Assembly.

Total Hours: 45

REFERENCES:

1. COLONEL WM. T. MCLYMAN, TRANSFORMER AND INDUCTOR DESIGN, Third Edition, Revised and Expanded © Copyright © 2004 by Marcel Dekker, Inc.
2. Charles A. *Harper, Handbook of Electronic Packaging,* McGraw-Hill Book Company, pp. 1-51-1-53.
3. W.G. Hurley, W.H. Wölfle Transformers and Inductors for Power Electronics *Theory, Design and Applications,* Wiley, February 2013
4. Vencislav Cekov Valchev, Alex Van den Bossche, Inductors and Transformers for Power Electronics, March 24, 2005 by CRC Press

OUTCOMES:

At the end of the course, the student is expected to possess knowledge and achieve skills on the following:

- Ability to design magnetics with faster and tighter control.
- Able to work on state-of-the-art design or high-volume or low-cost production.
- To analyze and design the planar transformer design and planar construction.
- To design lightweight, high-frequency aerospace transformers or low-frequency commercial transformers.
- Ability to use various approaches in arriving at suitable transformer and inductor designs.

EECY047	SPECIAL ELECTRICAL MACHINES AND CONTROLLERS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To impart knowledge on Construction, principle of operation and performance of switched reluctance motors.
- To understand the Construction, principle of operation and performance of SM.
- To impart knowledge on Construction, principle of operation and performance of AC commutator motors.
- To study about the Construction, principle of operation and performance of permanent magnet brushless D.C. motors and PMSM.
- To impart knowledge on Construction, principle of operation and performance of linear motors.
- To learn the softwares Magnet AND ANSYS for performance analysis of motor.

MODULE I SWITCHED RELUCTANCE MOTORS 07

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

MODULE II STEPPING MOTORS 07

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

MODULE III AC COMMUTATOR MOTORS 07

Principle of operation – Equivalent circuit – Phasor diagram – Performance of Repulsion motor and Universal motor.

MODULE IV PERMANENT MAGNET MOTORS 07

Principle of operation – types – magnetic circuit analysis – EMF and Torque equations – Power Controllers – Motor characteristics and control of PMSM and BLDC motors.

MODULE V LINEAR MOTORS 07

Linear Induction motor (LIM) classification – construction – Principle of operation – Concept of current sheet – goodness factor – DC Linear motor (DCLM) types –

circuit equation , DCLM control applications ,Linear Synchronous motor(LSM) – Types - Performance equations – Applications.

MODULE VI CASE STUDY 10

Modeling and simulation – Switched Reluctance Machines – Permanent magnet BLDC Motor – PMSM – MAGNET 6.0, ANSYS software.

Total Hours: 45

REFERENCES:

1. Taylor E O, “The performance and design of AC Commutator motors”, Sir Issac Pitman & Sons, London, 1998.
2. Kenjo T, “Stepping Motors and their Microprocessor Controls”, Clarendon Press London, 1984.
3. Miller T J E, “Brushless Permanent Magnet and Reluctance Motor Drives”, Clarendon Press, Oxford, 1989.
4. Naser A and Boldea L,”Linear Electric Motors: Theory Design and Practical Applications”, Prentice Hall Inc., New Jersey 1987.

OUTCOMES:

At the end of the course, the student is expected to possess knowledge and achieve skills on the following:

- Talent in selection of motor for various application
- A thorough understanding of various special electric machines and their applications.
- Able to analyse any electric machine.
- Ability to model small power rating of motor for real time application
- Software knowledge in Magnet, ANSYS for electrical application.
- Able to present the rudiments of linear machines.

ECY048 VECTOR CONTROL OF AC DRIVES

L	T	P	C
3	0	0	3

OBJECTIVES:

- To impart knowledge, on advanced aspects of AC drives
- To prepare the students to analyze Vector control of IM drives..
- To prepare the students to analyze advanced control aspects of synchronous machines.
- To prepare the students to analyze control of special machines

MODULE I CONTROL OF INDUCTION MOTOR DRIVES I 08

Principle of Vector control of IM drives – Direct torque control – Direct flux control – torque, voltage and current equations – problems.

MODULE II CONTROL OF INDUCTION MOTOR DRIVES II 07

Sensorless control of IM drives – Flux Observers – Multi-level converter fed IM drive – Utility friendly IM drive.

MODULE III CONTROL OF SYNCHRONOUS MOTOR DRIVE 07

Self controlled SM drives – Vector control of SM drives – Cyclo-converter fed SM machines – torque and speed control of SM drives (including sensorless).

MODULE IV CONTROL OF SPECIAL ELECTRIC DRIVES 07

Control of: PM drives – PM Synchronous Motor drives – Brushless DC motor – switched reluctance motor – stepper motor

MODULE V PARAMETER SENSITIVITY AND SATURATION EFFECTS 08

Phasor diagram for detuned operation: Field orientation flux, Torque characteristics – influence of saturation – transient response : Torque response with slip gain error- optimal selection of flux level.

MODULE VI FLUX WEAKENING OPERATION 08

Maximum Speed - Voltage Limit Eclipse - Flux Weakening Operation Scheme - Flux Weakening Control Schemes: Indirect Flux Weakening Algorithm and controllers - Model - free control schemes : six step and Adaptive control - and Model – based control schemes: direct and Indirect control of Flux.

Total Hours: 45

REFERENCES

1. Bimal K. Bose ,Power Electronics and Variable Frequency Drives
2. *Technology and Applications,* Institute of Electrical and Electronics Engineers, Inc.
3. D. W. Novotny, T. A. Lipo, Vector Control and Dynamics of AC Drives, Clarendon Press, 1996 - Technology & Engineering
4. Bin Wu High-Power Converters and AC Drives, John Wiley & Sons, 17-Feb-2006 - Technology & Engineering
5. Haitham Abu-Rub, Atif Iqbal ,Jaroslaw Guzinski ,High Performance Control Of Ac Drives With Matlab/Simulink Models , 2012 John Wiley & Sons Ltd

OUTCOMES

- Able to develop induction motor models for variable speed operations using scalar and vector control techniques.
- Apply the knowledge of sensors which can be used for controllers and synchronous machines.
- Able to implement Field oriented control (FOC) for synchronous motor, BLDC motors and PMSM motor.
- Able to analyze the characteristics of flux and flux weakening operation.

EECY049	SOLAR AND ENERGY STORAGE SYSTEM	L	T	P	C
		3	0	0	3

OBJECTIVES

- To Study about solar modules and PV system design and their applications
- To Deal with grid connected PV systems
- To Discuss about different energy storage systems

MODULE I INTRODUCTION 06

Characteristics of sunlight – semiconductors and P-N junctions –behaviour of solar cells – cell properties – PV cell interconnection

MODULE II STAND ALONE PV SYSTEM 08

Solar modules – storage systems – power conditioning and regulation - protection – stand alone PV systems design – sizing

MODULE III GRID CONNECTED PV SYSTEMS 09

PV systems in buildings – design issues for central power stations – safety – Economic aspect – Efficiency and performance - International PV programs

MODULE IV POWER CONDITIONING SCHEMES 08

DC Power conditioning Converters - Maximum Power point tracking algorithms - AC Power conditioners Synchronized operation with grid supply - Harmonic problem – building integrated PV systems.

MODULE V ENERGY STORAGE SYSTEMS 08

Impact of intermittent generation – Battery energy storage – solar thermal energy storage – pumped hydroelectric energy storage

MODULE VI APPLICATIONS 06

Water pumping – battery chargers – solar car – direct-drive applications –Space – Telecommunications.

Total : 45 Periods

TEXT BOOKS

1. Eduardo Lorenzo G. Araujo, Solar electricity engineering of photovoltaic systems, Progensa,1994.

2. Stuart R.Wenham, Martin A.Green, Muriel E. Watt and Richard Corkish, Applied Photovoltaics, 2007,Earthscan, UK.

REFERENCES

1. Frank S. Barnes & Jonah G. Levine, Large Energy storage Systems Handbook , CRC Press, 2011.
2. Solar & Wind energy Technologies – McNeils, Frenkel, Desai, Wiley Eastern, 1990
3. Solar Energy – S.P. Sukhatme, Tata McGraw Hill, 1987.

OUTCOMES:

Students will develop more understanding on solar energy storage systems:

- Students will develop basic knowledge on standalone PV system
- Students will understand the issues in grid connected PV systems
- Able to develop various power conditioning schemes for solar systems.
- Able to explain the Grid connected PV systems.
- Students will study about the modelling of different energy storage systems and their performances
- Students will attain more on different applications of solar energy

EECY050	FUNDAMENTALS OF GRID CONNECTED PHOTO-VOLTAIC POWER ELECTRONIC CONVERTER DESIGN	L	T	P	C
		3	0	0	3

MODULE I INTRODUCTION 04

Characteristics of sunlight – semiconductors and P-N junctions –behaviour of solar cells – cell properties – PV cell interconnection

MODULE II OVERVIEW OF PHOTO VOLTAIC SYSTEMS AND CONVERTERS 08

Grid connection standards, Solar Cell Characteristics, Solar panel and converter configurations, Converter topologies, Grid filter topologies, Temporary storage

MODULE III CONTROL OF PHOTO VOLTAIC CONVERTERS 09

Maximum power utilization of photo voltaic power sources, DC-DC Converter Control, DC- AC Converter control, Harmonic compensation, Grid synchronisation, Anti Islanding

MODULE IV POWER CONDITIONING SCHEMES 09

DC Power conditioning Converters - Maximum Power point tracking algorithms - AC Power conditioners Synchronized operation with grid supply - Harmonic problem – building integrated PV systems.

MODULE V SYSTEM DESCRIPTION, MODELLING AND OPTIMIZATION 09

Converter topology and control description, P&O Maximum Power Point Tracker optimization, Phase Locked Loop PI Regulator, Current Regulator,Voltage Controller , Complete control system model.

MODULE VI SIMULATIONS 06

DC-DC Converter, DC-AC Converter- PLL, Current control, Voltage control, The LCL filter.

Total Hours: 45

TEXT BOOKS

1. Svein Erik Evju, Fundamentals of Grid Connected Photo-Voltaic Power Electronic Converter Design', Norwegian University of Science and Technology.

REFERENCES

1. Eduardo Lorenzo G. Araujo, Solar electricity engineering of photovoltaic systems, Progensa,1994. 2. Stuart R.Wenham, Martin A.Green, Muriel E. Watt and Richard Corkish, Applied Photovoltaics, 2007,Earthscan, UK.
2. Frank S. Barnes & Jonah G. Levine, Large Energy storage Systems Handbook, CRC Press, 2011.
3. Solar & Wind energy Technologies – McNeils, Frenkel, Desai, Wiley Eastern, 1990
4. Solar Energy – S.P. Sukhatme, Tata McGraw Hill, 1987.

OUTCOMES:

- Will become familiar with the operation of the components of PV systems, including solar modules, power control components, and the balance of system components.
- Able to carry out a credible design of a grid-connected PV system.
- Able to model and design MPPT and controllers of grid tied inverters.
- Use of simulation software for energy yield estimation

EECY051 SOLAR POWER SYSTEMS DESIGN

L	T	P	C
3	0	0	3

OBJECTIVES:

- To impart knowledge, analyze and to design the modern semi-conductor devices and their applications in power Electronic controller for rectification, inversion, frequency conversion with improved performance.

MODULE I SOLAR POWER SYSTEM PHYSICS 07

Solar Cell Physics - Solar Cell Electronics - Types of Solar Cells Technologies - Concentrators - Solar Panel Arrays - Solar Power System Components.

MODULE II SOLAR POWER TECHNOLOGIES 08

Solar Power System Components - Crystalline Solar Photovoltaic Module Production - Amonix Megaconcentrators - Film Technologies - Solar Photovoltaic System Power Research and Development.

MODULE III SOLAR POWER SYSTEM DESIGN 09

Solar Power System Components and Materials - - Storage Battery Technologies - Solar Power System Wiring - Considerations for - Lightning Protection - Central Monitoring and Logging System Requirements - Ground-Mount and Roof-Mount Photovoltaic Module Installations - Shading Analysis and Solar Energy Performance Multiplier - Site Evaluation - Solar Power Design.

MODULE IV SOLAR POWER GENERATION PROJECT IMPLEMENTATION 07

Designing a Typical Residential Solar Power System - Example of Typical Solar Power System Design and Installation Plans for a Single Residential Unit - Commercial Applications -Small-Scale Solar Power Pumping Systems -Large-Capacity Solar Power Pumping Systems - Pump Operation Characteristics - Semitropic Open Field Single-Axis Tracking System PV Array

MODULE V ECONOMICS OF SOLAR POWER SYSTEMS 06

Current Preliminary Engineering Design - Meteorological Data - Energy Cost Factor - Project Cost Analysis - Feasibility Study Report.

MODULE VI PASSIVE SOLAR HEATING TECHNOLOGIES 08

Passive Solar Water Heating - Pool Heating - Concentrator Solar Technologies - Solar Cooling and Air Conditioning - Direct Solar Power Generation - Innovations

in Passive Solar Power Technology.

Total Hours: 45

REFERENCES:

1. Mukund R. Patel, "Wind and Solar Power Systems Design, Analysis, and Operation", Published in 2006 by CRC Press, Taylor & Francis Group
2. Ned Mohan, Tore M. Undeland. "Power Electronics- Converters, Applications and Design", John Wiley & Sons (Asia) Private Ltd., 2003.
3. M.D.Singh , " Power Electronics"Tata McGraw-Hill Education, 07-Jul-2008
4. R W Erickson and D Makgimovic,"Fundamental of Power Electronics" Springer, 2001 2nd Edition.
5. Vedam Subrahmanyam, "Power Electronics", New Age International (P) Limited, New Delhi, 1997.
6. D.M.Mitchell, DC-DC Switching Regulator Analysis McGraw-Hill Ryerson, Limited, 1988

OUTCOMES:

At the end of the course, the student is expected to possess knowledge and achieve skills on the following

- Understand the characteristics of solar cell.
- Understand the constructional details of solar panel.
- Know about the monitoring and commissioning of solar panel
- Know about the solar pumping and mechanical tracking of solar power generation system.
- Cost analysis of solar power generation system.

EECY052	SWITCHED MODE POWER CONVERSION SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To apply the basic concepts of power electronics for designing converters and protection circuits.
- To apply mathematics in analyzing switching converter circuit performance.
- To solve engineering problems related to switching converters.
- To understand the modeling of the switched mode power converter.
- Design and implement practical circuits for UPS, SMPS etc.

MODULE I SWITCHED MODE POWER CONVERSION – OVERVIEW 07

Overview of switched mode power conversion, Prior art, Power semi conductor switches – ideal, non ideal switch characteristics, issues related to switches. Design of Transformer, inductor, capacitor for SMPS.

MODULE II DC – DC CONVERTERS 08

Introduction to DC – DC Converters, Continuous and Dis- continuous operation of DC- DC Converters Primitive converter, Non- isolated converter, Isolated Converters – Performance analysis under ideal and non ideal conditions.

MODULE III MODELING OF CONVERTERS 08

Modeling of DC – DC converter- State space representation - Circuit Averaging – DC-DC converter controller structure

MODULE IV CONTROLLER DESIGN FOR DC-DC CONVERTER 08

Controllers and Sensing Circuit, Current Control, Implementation of PID controller for DC- DC converter – Controller Design, Regulation of Multiple outputs

MODULE V STABILITY AND CONTROL-LOOP COMPENSATION IN SMPS 08

Causes of Instability in Switch mode Supplies - Methods of Stabilizing the Loop - Stability Testing Methods - Test Procedure Transient Testing Analysis - Bode Plots - Measurement-Procedures for Bode Plots of Closed - Loop Power Supply Systems - Test Equipment for Bode Plot Measurement - Test Techniques - Measurement Procedures for Bode Plots of Open-Loop Power Supply Systems - Establishing Optimum Compensation Characteristic by the “Difference Method” - Some Causes of Stubborn Instability – Problems

MODULE VI SIMULATION EXERCISES 06

Complete closed loop controller design for: dc-dc systems – Step down, boost, isolated converters - System id tool based linearization model creation by Matlab

Total Hours: 45

REFERENCES:

1. M.H.Rashid, " Power Electronics Handbook", Elsevier Press,2005.
2. Nihal Kularatna, "Power Electronics Design Handbook: Low Power
1. Components and Applications", 2012.
2. Keith.H.Sueker, "Power Electronics Design:A Practitioner's Guide", 2003.
3. Issa Batarseh, "Power Electronic Circuits ", John Wiley, 2004.
4. Philip T Krein, "Elements of Power Electronics ",Oxford Press,1997.
5. Mohan, Un del and and Robbins; Power Electronics: Converters, Applications
6. and Design, John Wiley and Sons, 2011.
7. Umanand.L, Power Electronics: Essentials and Applications, Wiley India, 2009.
8. Umanand.L, Bhat,S.R., Design of Magnetic Components for Switched Mode
9. Power Converters, Wiley Eastern Publication, 1992.

OUTCOMES:

At the end of the course, the student is expected to possess knowledge and achieve skills on the following:

- Understand the importance of switched mode power conversion
- Ability to design DC-Dc converter
- Ability to design controller circuit for DC – DC Converter
- Ability to design and implement switched mode power conversion devices.
- Ability to choose appropriate power converter topologies and design the power stage and feedback controllers for various applications

EEC6101 SYSTEMS THEORY

L	T	P	C
3	0	0	3

OBJECTIVES:

- To provide knowledge on state space approach, state feedback controllers and observers for different processes.
- To enhance knowledge on stability analysis of multivariable processes.
- To introduce nonlinear systems and its linearization methods.
- To evaluate Stability of Linear and Non Linear Systems.

MODULE I STATE SPACE APPROACH 08

Introduction to State Space Approach - System representation in state variable form – State transition equation – Methods of computing the state transition matrix.

MODULE II STATE FEEDBACK CONTROL AND STATE ESTIMATOR 08

Stability analysis - Controllability and Observability of linear time invariant systems - State Feedback – Output Feedback – Pole placement technique – Full order and Reduced Order Observers.

MODULE III STABILITY FOR LINEAR SYSTEMS 08

Introduction – Equilibrium points – Stability in the sense of Lyapunov - BIBO Stability – Stability of LTI systems – The direct method of Lyapunov and the Linear continuous time autonomous systems – Popov Stability Criterion.

MODULE IV NON-LINEAR SYSTEMS 06

Types of Non-Linearity – Typical Examples – Phase plane analysis (analytical and graphical methods) – Limit cycles – Equivalent Linearization.

MODULE V STABILITY FOR NON-LINEAR SYSTEMS 08

Equilibrium stability of non linear continuous time autonomous systems – Finding Lyapunov functions for nonlinear continuous time autonomous systems – Krasovskii and variable gradient method.

MODULE VI STABILITY FOR NON-LINEAR SYSTEMS USING DESCRIBING FUNCTION 07

Describing Function Analysis for Non Linear Systems, Describing Functions for different non-linear elements- backlash, deadzone, saturation and hysteresis.

Total Hours: 45

REFERENCES:

1. M.Gopal, “Modern Control System Theory”, New Age International, 2005.
2. K.Ogata, “Modern Control Engineering”, Prentice Hall of India, 2002.
3. John .S.Bay, “Fundamentals of Linear State Space Systems”, Tata McGraw Hill, 1999.
4. Z.Bubnicki, “Modern Control Theory”, Springer, 2005.

OUTCOMES:

At the end of the course, the students will have knowledge and achieve skills on the following:

- Implement state space approach for the process and obtain the solution.
- Design state feedback controller and observers.
- Perform stability analyses of the system using conventional mathematical approach
- Ability to analyze complex systems using mathematical models.
- Ability to analyze the stability of Linear Systems using Lyapnov and Popov Stability Criterions
- Ability to analyze the stability of Non-Linear Systems using novel techniques.

GENERAL ELECTIVES

GECY101 PROJECT MANAGEMENT

L	T	P	C
3	0	0	3

OBJECTIVES:

The objectives of the course would be to make the students

- Learn to e valuate and choose an optimal project and build a project profile.
- Attain knowledge on risk identification and risk analysis
- Gain insight into a project plan and components
- Familiar with various gamut of technical analysis for effective project implementation
- Learn to apply project management techniques to manage resources.

MODULE I INTRODUCTION & PROJECT INITIATION 09

Introduction to project and project management - projects in contemporary organization – The project life cycle - project initiation - project evaluation methods & techniques - project selection criteria - project profile.

MODULE II RISK ANALYSIS 09

Sources of risk: project specific - competitive - industry specific - market and international risk – perspectives of risk – risk analysis: sensitivity analysis - scenario analysis - breakeven analysis - simulation analysis - decision tree analysis – managing/mitigating risk – project selection under risk.

MODULE III PROJECT PLANNING & IMPLEMENTATION 09

Project planning – importance – functions - areas of planning - project objectives and policies - steps in planning process - WBS – capital requirements - budgeting and cost estimation - feasibility analysis - creation of project plan – project implementation: pre-requisites - forms of project organization

MODULE IV TECHNICAL ANALYSIS 09

Technical analysis for manufacturing/construction/infrastructure projects – process/technology - materials and inputs - product mix - plant capacity – plant location and site selection – plant layout - machinery and equipment – structures and civil works – schedule of project implementation – technical analysis for software projects.

MODULE V PROJECT MANAGEMENT TECHNIQUES 09

Project scheduling - network construction – estimation of project completion time – identification of critical path - PERT & CPM – crashing of project network - complexity of project scheduling with limited resources - resource allocation - resource leveling – resource smoothing – overview of project management software.

Total Hours: 45

REFERENCES:

1. Projects: Planning, Analysis, Financing, Implementation and Review, Prasanna Chandra, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004.
2. Project Management and Control, Narendra Singh, Himalaya Publishing, New Delhi, 2015.
3. A Management Guide to PERT/CPM, Jerome, D. Weist and Ferdinand K. Levy, Prentice Hall of India, New Delhi, 1994.

OUTCOMES:

On successfully completing this course, the student will be able to:

- Evaluate & select a project as well as develop a project profile.
- Identify various risks associated with the project and manage it effectively.
- Prepare a detailed project plan addressing its components.
- Perform technical analysis for effective project implementation
- Apply project management techniques for maximizing resource utilization.

GECY102 SOCIETY, TECHNOLOGY & SUSTAINABILITY

L	T	P	C
3	0	0	3

OBJECTIVES:

- To aware of new technologies through advances in Science and Engineering.
- To make them realise the profound impact on society.
- To understand the ethical issues raised by technological changes and its effect on society.
- To introduce students a broad range of perspectives on the adoption and use of technologies.
- To make them realize the need of sustainability in the context of emerging technologies.

MODULE I TECHNOLOGY AND ITS IMPACTS 09

Origin and evolution of technologies – Nature of technology- Innovation – Historical Perspective of technology – Sources of technological change - Co-evolution of technology and economy – Scientific knowledge and technological advance – Science and Engineering aspects of Technology – Impact on the Society – Social and Ethical Issues associated with technological change – Social and environmental consequences - Impact of technological change on human life – Technology and responsibility – Technology and social justice.

MODULE II TECHNOLOGY AND ITS ADVANCEMENT 09

Sociological aspects of technology – Ethics and technology – Technology and responsibility – International Economics, Globalisation and Human Rights – Sustainability and Technology – Population and environment - Technology, Energy and Environment – Organisations and technological change.

MODULE III SOCIETY AND TECHNOLOGY 09

Impact of technologies on contemporary society – Role of society in fostering the development of technology – Response to the adaption and use of technology – Impact of technology on developer and consumers – Technological change and globalisation.

MODULE IV IMPACT OF A SPECIFIC TECHNOLOGY ON HUMAN WELFARE 09

Impact of the following technologies on Human life – Medical and Biomedical – Genetics Technology – Electronics and Communications – Electronic media

Technology – Information Systems Technology – Nanotechnology – Space Technology and Energy Technology.

MODULE V THE IMPORTANCE OF SUSTAINABILITY 09

Sustainability – A brief history – Concepts and contexts for sustainability – Ecological imbalance and biodiversity loss – Climate change – Population explosion. Industrial ecology – systems approach to sustainability – Green engineering and technology- sustainable design- sustainable manufacturing- Green consumer movements – Environmental ethics – Sustainability of the planet Earth – Future planning for sustainability.

Total Hours: 45

REFERENCES:

1. Volti Rudi, “Society and Technology Change”, 6th Edition, Worth publishers Inc, USA, 2009.
2. Arthur W.A, “The nature of Technology: What it is and how it evolves”, Free Press, NY, USA, 2009.
3. Winston M and Edelbach R, “Society, Ethics and Technology”, 3rd Edition, San Francisco, USA, 2005.
4. Martin A.A Abraham, “Sustainability Science and Engineering: Defining Principles”, Elsevier Inc, USA, 2006.
5. R.V.G.Menon, “Technology and Society”, Pearson Education, India, 2011.

OUTCOMES:

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

- Understand the benefits of modern technology for the well-being of human life.
- Connect sustainability concepts and technology to the real world challenges.
- Find pathway for sustainable society.

GECY103 ARTIFICIAL INTELLIGENCE

L	T	P	C
3	0	0	3

OBJECTIVES:

- Expose the history and foundations of artificial intelligence.
- Showcase the complexity of working on real time problems underlying the need for intelligent approaches.
- Illustrate how heuristic approaches provide a good solution mechanism.
- Provide the mechanisms for simple knowledge representation and reasoning.
- Highlight the complexity in working with uncertain knowledge.
- Discuss the current and future applications of artificial intelligence.

MODULE I HISTORY AND FOUNDATIONS 08

History – Scope – Influence from life – Impact of computing domains - Agents in environments - Knowledge representation – Dimensions of Complexity – Sample application domains – Agent structure.

MODULE II SEARCH 10

Problem solving as search – State spaces – Uninformed Search – Heuristic search – Advanced search – Constraint satisfaction - Applications.

MODULE III KNOWLEDGE REPRESENTATION AND REASONING 10

Foundations of knowledge representation and reasoning, representing and reasoning about objects, relations, events, actions, time, and space predicate logic, situation calculus, description logics, reasoning with defaults, reasoning about knowledge, sample applications.

MODULE IV REPRESENTING AND REASONING WITH UNCERTAIN KNOWLEDGE 08

Probability, connection to logic, independence, Bayes rule, Bayesian networks, probabilistic inference, sample applications.

MODULE V CASE STUDY AND FUTURE APPLICATIONS 09

Design of a game / Solution for problem in student's domain. Natural Language processing, Robotics, Vehicular automation – Scale, Complexity, Behaviour – Controversies.

Total Hours: 45

TEXT BOOK:

1. Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, Prentice Hall, Third Edition, 2010.
2. David Poole, Alan Mackworth, Artificial Intelligence: Foundations of Computational Agents, Cambridge University Press, 2010.
3. Nils J. Nilsson, The Quest for Artificial Intelligence, Cambridge University Press, Online edition, 2013.
4. Keith Frankish, William M. Ramsey (eds) The Cambridge Handbook of Artificial Intelligence, Cambridge University Press, 2014.

OUTCOMES:

Students who complete this course will be able to

- Discuss the history, current applications, future challenges and the controversies in artificial intelligence.
- Apply principle of AI in the design of an agent and model its actions.
- Design a heuristic algorithm for search problems.
- Analyze and represent the fact using logic for a given scenario
- Represent uncertainty using probabilistic models
- Develop a simple game or solution using artificial intelligence techniques.

GECY104 GREEN COMPUTING

L	T	P	C
3	0	0	3

OBJECTIVES:

- To focus on the necessity of green computing technology.
- To expose to various issues with information technology and sustainability.
- To attain knowledge on the technologies for enabling green cloud computing.
- To elaborate on the energy consumption issues
- To illustrate a Green and Virtual Data Center
- To develop into a Green IT Technologist.

MODULE I INTRODUCTION 08

Trends and Reasons to Go Green - IT Data Center Economic and Ecological Sustainment - The Growing Green Gap: Misdirected Messaging, Opportunities for Action - IT Data Center “Green” Myths and Realities - PCFE Trends, Issues, Drivers, and Related Factors - Green Computing and Your Reputation- Green Computing and Saving Money- Green Computing and the Environment

MODULE II CONSUMPTION ISSUES 10

Minimizing power usage – Cooling - Electric Power and Cooling Challenges - Electrical – Power -Supply and Demand Distribution - Determining Energy Usage - From Energy Avoidance to Efficiency - Energy Efficiency Incentives, Rebates, and Alternative Energy Sources - PCFE and Environmental Health and Safety Standards- Energy-exposed instruction sets- Power management in power-aware real-time systems.

MODULE III NEXT-GENERATION VIRTUAL DATA CENTERS 09

Data Center Virtualization - Virtualization beyond Consolidation - Enabling Transparency - Components of a Virtual Data Center - Datacenter Design and Redesign - Greening the Information Systems - Staying Green- Building a Green Device Portfolio- Green Servers and Data Centers- Saving Energy

MODULE IV TECHNOLOGIES FOR ENABLING GREEN AND VIRTUAL DATA CENTERS 08

Highly Effective Data Center Facilities and Habitats for Technology - Data Center Electrical Power and Energy Management - HVAC, Smoke and Fire Suppression

- Data Center Location - Virtual Data Centers Today and Tomorrow - Cloud Computing, Out-Sourced, and Managed Services.

MODULE V SERVERS AND FUTURE TRENDS OF GREEN COMPUTING 10

Server Issues and Challenges - Fundamentals of Physical Servers - Types, Categories, and Tiers of Servers - Clusters and Grids - Implementing a Green and Virtual Data Center - PCFE and Green Areas of Opportunity- 12 Green Computer Companies- What's in Green computer science-Green off the Grid aimed for data center energy evolution-Green Grid Consortium- Green Applications- Green Computing Making Great Impact On Research

Total Hours: 45

REFERENCES:

1. Bud E. Smith,"Green Computing Tools and Techniques for Saving Energy, Money, and Resources", Taylor & Francis Group, CRC Press, ISBN-13: 978-1-4665-0340-3, 2014.
2. Jason Harris, "Green Computing and Green IT Best Practices, On Regulations and Industry Initiatives, Virtualization and power management, materials recycling and Tele commuting, Emereo Publishing .ISBN-13: 978-1-9215-2344-1,2014.
3. Ishfaq Ahmed & Sanjay Ranka, "Handbook of Energy Aware and Green Computing", CRC Press, ISBN: 978-1-4665-0116-4, 2013.
4. Kawahara, Takayuki, Mizuno, "Green Computing with Emerging Memory", Springer Publications, ISBN:978-1-4614-0811-6, 2012
5. Greg Schulz, "The Green and Virtual Data Center", CRC Press, ISBN-13:978-1-4200-8666-9, 2009.
6. Marty Poniatowski, "Foundation of Green IT: Consolidation, Virtualization, Efficiency, and ROI in the Data Center", Printice Hall, ISBN: 9780-1-3704-375-0, 2009.

OUTCOMES:

Students who complete this course will be able to

- Demonstrate issues relating to a range of available technologies, systems and practices to support green computing.
- Select appropriate technologies that are aimed to reduce energy consumption.
- Address design issues needed to achieve an organizations' green

computing objectives.

- Analyze the functionality of Data Centers.
- Critically evaluate technologies and the environmental impact of computing resources for a given scenario.
- Compare the impact of Green Computing with other computing techniques.

GECY105 GAMING DESIGN

L	T	P	C
3	0	0	3

OBJECTIVES:

- To master event-based programming
- To learn resource management as it relates to rendering time, including level-of-detail and culling.
- To become familiar with the various components in a game or game engine.
- To explore leading open source game engine components.
- To become familiar of game physics.
- To be compatible with game animation.

MODULE I INTRODUCTION 09

Magic Words – What Skills Does a Game Designer Need? – The Most Important Skill -The Five Kinds of Listening-The Secret of the Gifted.

MODULE II THE DESIGNER CREATES AN EXPERIENCE 09

The Game Is Not the Experience -Is This Unique to Games? -Three Practical Approaches to Chasing Rainbows -Introspection: Powers, Perils, and Practice -Dissect Your Feelings -Defeating Heisenberg -Essential Experience.

MODULE III THE EXPERIENCE IN THE PLAYER MIND AND GAME MECHANICS 08

Modeling – Focus -Empathy – Imagination – Motivation – Space – Objects, Attributes, and States – Actions – Rules.

MODULE IV GAMES THROUGH AN INTERFACE 09

Breaking it Down – The Loop of Interaction – Channels of Information – Other Interface.

MODULE V BALANCED GAME MECHANICS 10

Balance – The Twelve Most Common Types of Game Balance – Game Balancing Methodologies - Balancing Game Economies.

Total Hours: 45

REFERENCES:

1. Jesse Schell, "The Art of Game Design: A Book of Lenses", 2nd Edition

ISBN-10: 1466598646, 2014.

2. Ashok Kumar, Jim Etheredge, Aaron Boudreaux, “Algorithmic and Architectural Gaming Design: Implementation and Development", 1st edition, Idea Group, U.S ISBN-10: 1466616342, 2012.
3. Katie Salen Tekinba, Melissa Gresalfi, Kylie Peppler, Rafi Santo, "Gaming the System - Designing with Gamestar Mechanic" MIT Press , ISBN-10: 026202781X, 2014.
4. James M. Van Verth, Lars M. Bishop "Essential Mathematics for Games and Interactive Applications", Third Edition, A K Peters / CRC Press, ISBN-10: 1482250926, 2015.

OUTCOMES:

Students who complete this course will be able to

- Realize the basic history and genres of games
- Demonstrate an understanding of the overall game design process
- Explain the design tradeoffs inherent in game design
- Design and implement basic levels, models, and scripts for games
- Describe the mathematics and algorithms needed for game programming
- Design and implement a complete three-dimensional video game

GECY106 SOCIAL COMPUTING

L	T	P	C
3	0	0	3

OBJECTIVES:

- To create original social applications, critically applying appropriate theories and effective practices in a reflective and creative manner.
- To critically analyze social software in terms of its technical, social, legal, ethical, and functional features or affordances.
- To encourage the development of effective communities through the design, use, and management of social software.
- To give students with a base of knowledge and advances for them to critically examine existing social computing services.
- To plan and execute a small-scale research project in social computing in a systematic fashion.
- To become familiar with the concept of computational thinking.

MODULE I BASIC CONCEPTS 09

Networks and Relations: Relations and Attributes, Analysis of Network Data, Interpretation of network data -New Social Learning – Four Changes that Shift Work - Development of Social Network Analysis: Sociometric analysis and graph theory, Interpersonal Configurations and Cliques – Analysing Relational Data.

MODULE II SOCIAL LINK 09

Individual Actors, Social Exchange Theory, Social Forces, Graph Structure, Agent Optimization Strategies in Networks – Hierarchy of Social Link Motivation- Social Context.

MODULE III SOCIAL MEDIA 08

Trends in Computing – Motivations for Social Computing – Social Media: Social relationships, Mobility and Social context – Human Computation – Computational Models- Business use of social Media.

MODULE IV SOCIAL INFORMATION FILTERING 09

Mobile Location Sharing – Location based social media analysis – Social Sharing and Social Filtering – Automated recommender Systems – Traditional and Social Recommender Systems.

MODULE V SOCIAL NETWORK STRATEGY 10

Application of Topic Models – Opinions and Sentiments – Recommendation Systems – Language Dynamics and influence in online communities – Psychometric analysis – Case Study: Social Network Strategies for surviving the zombie apocalypse.

Total Hours: 45

REFERENCES:

1. Tony Bingham, Marcia Conner, “The New Social Learning, Connect. Collaborate. Work”, 2nd Edition, ATD Press, ISBN-10:1-56286-996-5, 2015.
2. Nick Crossley, Elisa Bellotti, Gemma Edwards, Martin G Everett, Johan Koskinen, Mark Tranmer, “Social Network Analysis for Ego-Nets”, SAGE Publication, 2015.
3. Zafarani, Abbasi and Liu, Social Media Mining: An Introduction, Cambridge University Press, 2014.
4. Christina Prell, “Social Network Analysis: History, Theory and Methodology”, 1st Edition, SAGE Publications Ltd, 2012.
5. John Scott, “Social Network Analysis”, Third Edition, SAGE Publication, 2013.
6. Jennifer Golbeck, “Analyzing the Social Web”, Elsevier Publication, 2013.
7. Huan Liu, John Salerno, Michael J. Young, “Social computing and Behavioral Modeling”, Springer Publication, 2009.

OUTCOMES:

Students who complete this course will be able to

- Realize the range of social computing applications and concepts.
- Analyze data left after in social media.
- Recognize and apply the concepts of computational models underlying social computing.
- Take out simple forms of social diagnostics, involving network and language models, applying existing analytic tools on social information.
- Evaluate emerging social computing applications, concepts, and techniques in terms of key principles.
- Design and prototype new social computing systems.

GECY107 SOFT COMPUTING

L	T	P	C
3	0	0	3

OBJECTIVES:

The aim of the course is to

- Enumerate the strengths and weakness of soft computing
- Illustrate soft computing methods with other logic driven and statistical method driven approaches
- Focus on the basics of neural networks, fuzzy systems, and evolutionary computing
- Emphasize the role of euro-fuzzy and hybrid modeling methods
- Trace the basis and need for evolutionary computing and relate it with other soft computing approaches

MODULE I SOFT COMPUTING - BASICS 06

Soft computing – Hard Computing – Artificial Intelligence as the basis of soft computing – Relation with logic driven and statistical method driven approaches- Expert systems – Types of problems: Classification, Functional approximation, Optimizations – Modeling the problem – Machine Learning – Hazards of Soft Computing – Current and future areas of research

MODULE II ARTIFICIAL NEURAL NETWORK 12

Artificial Neuron – Multilayer perceptron – Supervised learning – Back propagation network –Types of Artificial Neural Network: Supervised Vs Un Supervised Network – Radial basis function Network – Self Organizing Maps – Recurrent Network – Hopfield Neural Network – Adaptive Resonance Theory – Issues in Artificial Neural Network – Applications

MODULE III FUZZY SYSTEMS 09

Fuzzy Logic – Membership functions – Operators – Fuzzy Inference systems – Other sets: Rough sets, Vague Sets – Fuzzy controllers - Applications

MODULE IV NEURO FUZZY SYSTEMS 09

Cooperative Neuro fuzzy systems – Neural network driven fuzzy reasoning – Hybrid Neuro fuzzy systems – Construction of Neuro Fuzzy systems: Structure Identification phase, Parameter learning phase – Applications

MODULE V EVOLUTIONARY COMPUTING 09

Overview of evolutionary computing – Genetic Algorithms and optimization –

Genetic Algorithm operators – Genetic algorithms with Neural/Fuzzy systems – Variants of Genetic Algorithms– Population based incremental learning – Evolutionary strategies and applications

Total Hours: 45

TEXTBOOKS:

1. Samir Roy, “Introduction to Soft Computing: Neuro-Fuzzy and Genetic Algorithms”, Pearson, 2013
2. Anupam Shukla, Ritu Tiwari and Rahul Kala, “Real life applications of Soft Computing”, CRC press, 2010.
3. Fakhreddine O. Karray, “Soft Computing and Intelligent Systems Design: Theory, Tools and Applications”, Pearson, 2009

OUTCOMES:

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

- Enumerate the theoretical basis of soft computing
- Explain the fuzzy set theory
- Discuss the neural networks and supervised and unsupervised learning networks
- Demonstrate some applications of computational intelligence
- Apply the most appropriate soft computing algorithm for a given situation

GECY108 EMBEDDED SYSTEM PROGRAMMING

L	T	P	C
3	0	0	3

OBJECTIVES:

- To introduce the design of embedded computing systems with its hardware and software architectures.
- To describe entire software development lifecycle and examine the various issues involved in developing software for embedded systems.
- To analyze the I/O programming and Embedded C coding techniques
- To equip students with the software development skills necessary for practitioners in the field of embedded systems.

MODULE I INTRODUCTION OF EMBEDDED SYSTEM 09

Embedded computing – characteristics and challenges – embedded system design process – Overview of Processors and hardware units in an embedded system – Compiling, Linking and locating – downloading and debugging – Emulators and simulators processor – External peripherals – Memory testing – Flash Memory.

MODULE II SOFTWARE TECHNOLOGY 09

Software Architectures, Software development Tools, Software Development Process Life Cycle and its Model, Software Analysis, Design and Maintenance.

MODULE III INPUT/OUTPUT PROGRAMMING 09

I/O Instructions, Synchronization, Transfer Rate & Latency, Polled Waiting Loops, Interrupt – Driven I/O, Writing ISR in Assembly and C, Non Maskable and Software Interrupts

MODULE IV DATA REPRESENTATION IN EMBEDDED SYSTEMS 09

Data representation, Twos complement, Fixed point and Floating Point Number Formats, Manipulating Bits in -Memory, I/O Ports, Low level programming in C, Primitive data types, Arrays, Functions, Recursive Functions, Pointers, Structures & Unions, Dynamic Memory Allocation, File handling, Linked lists, Queues, Stacks.

MODULE V EMBEDDED C 09

Embedded Systems programming in C – Binding & Running Embedded C program in Keil IDE – Dissecting the program - Building the hardware. Basic techniques for reading & writing from I/O port pins – switch bounce - LED Interfacing using Embedded C.

Total Hours: 45

REFERENCES:

1. Marilyn Wolf, "Computers as components ", Elsevier, 2012.
2. Qing Li and Carolyn Yao, "Real-Time Concepts for Embedded Systems", CMP Books, 2003.
3. Daniel W. Lewis, "Fundamentals of embedded software where C and assembly meet", Pearson Education
4. Michael Bass, "Programming Embedded Systems in C and C++", Oreilly, 2003.

OUTCOMES:

On completion of this course the student will be able to

- Design the software and hardware components in embedded system
- Describe the software technology
- Use interrupt in effective manner
- Use keil IDE for programming
- Program using embedded C for specific microcontroller
- Design the embedded projects

GECY109 PRINCIPLES OF SUSTAINABLE DEVELOPMENT

L	T	P	C
3	0	0	3

OBJECTIVES:

- To impart knowledge in the concepts and dimensions of sustainable development.
- To gain knowledge on the framework for achieving sustainability.

MODULE I CONCEPT OF SUSTAINABLE DEVELOPMENT 09

Environment and Development - Population poverty and Pollution – Global and Local environmental issues – Resource Degradation- Greenhouse gases – Desertification-industrialization – Social insecurity, Globalization and environment. History and emergence of the concept of sustainable development-Objectives of Sustainable Development.

MODULE II COMPONENTS AND DIMENSIONS OF SUSTAINABLE DEVELOPMENT 09

Components of Sustainability – Complexity of growth and equity – Social economic and environmental dimensions of sustainable development – Environment – Biodiversity – Natural – Resources – Ecosystem integrity – Clean air and water – Carrying capacity – Equity, Quality of Life, Prevention, Precaution – Preservation and Public Participation Structural and functional linking of developmental dimensions.

MODULE III FRAMEWORK FOR ACHIEVING SUSTAINABILITY 09

Operational guidelines – interconnected prerequisites for sustainable development Empowerment of Women, children, Youth, Indigenous People, Non-Governmental Organizations Local Authorities, Business and industry – Science and Technology for sustainable development – performance indicators of sustainability and assessment mechanism – Constraints and barriers for sustainable development.

MODULE IV SUSTAINABLE DEVELOPMENT OF SOCIO ECONOMIC SYSTEMS 09

Demographic dynamics of sustainability – Policies for socio-economic development – Strategies for implementing eco-development programmes Sustainable development through trade – Economic growth – Action plan for implementing sustainable development – Urbanization and sustainable Cities – Sustainable Energy and Agriculture – sustainable livelihoods.

MODULE V SUSTAINABLE DEVELOPMENT AND INTERNATIONAL RESPONSE 09

Role of developed countries in the development of developing countries – international summits – Stockholm to Johannesburg – Rio principles – Agenda-Conventions – Agreements – Tokyo Declaration – Doubling statement – Tran boundary issues integrated approach for resources protection and management

Total Hours: 45

REFERENCES:

1. Sayer J. and Campbell, B., The Science of Sustainable Development: Local Livelihoods and the Global environment - Biological conservation restoration & Sustainability, Cambridge university Press, London, 2003.
2. M.K. Ghosh Roy. and Timberlake, Sustainable Development, Ane Books Pvt. Ltd, 2011.
3. Mackenthun K.M., Concepts in Environmental Management, Lewis Publications London, 1999.
4. APJ Abdul Kalam and Srijan Pal Singh, Target 3 Billion: Innovative Solutions Towards Sustainable Development, Penguin India, 2011

OUTCOMES:

At the end of the course the student will be able to

- Describe the concepts of sustainable development
- Define the components and dimensions of sustainable development
- Outline the Frame work for achieving sustainability.
- State the policies and strategies for implementing sustainable development for Socio economic programmes.
- Examine the role of developed countries in sustainable development.

GECY110	QUANTITATIVE TECHNIQUES IN MANAGEMENT	L	T	P	C
		3	0	0	3

OBJECTIVE:

To impart knowledge on

- Concepts of operations research
- Inventory control in production management
- Financial management of projects
- Decision theory and managerial economics

MODULE I OPERATIONS RESEARCH 09

Introduction to Operations research – Linear programming – Graphical and Simplex Methods, Duality and Post-Optimality Analysis – Transportation and Assignment Problems

MODULE II PRODUCTION MANAGEMENT 09

Inventory control, EOQ, Quantity Discounts, Safety Stock – Replacement Theory – PERT and CPM – Simulation Models – Quality Control.

MODULE III FINANCIAL MANAGEMENT 09

Working Capital Management – Compound Interest and Present Value methods – Discounted Cash Flow Techniques – Capital Budgeting.

MODULE IV DECISION THEORY 09

Decision Theory – Decision Rules – Decision making under conditions of certainty, risk and uncertainty – Decision trees – Utility Theory.

MODULE V MANAGERIAL ECONOMICS 09

Cost concepts – Break even Analysis – Pricing techniques – Game Theory applications.

Total Hours: 45

REFERENCES:

1. Vohra, N.D. , Quantitative Techniques in Management, Tata McGraw Hill Co., Ltd, New Delhi, 2009.
2. Seehroeder, R.G., Operations Management, McGraw Hill, USA, 2002.
3. Levin, R.I, Rubin, D.S., and Stinsonm J., Quantitative Approaches to Management, McGraw Hill Book Co., 2008.

4. Frank Harrison, E., The Managerial Decision Making Process, Houghton Miffin Co. Boston, 2005.
5. Hamdy A. Taha, Operations Research- An Introduction, Prentice Hall, 2002.

OUTCOME:

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

- Apply the concepts of operations research for various applications
- Create models for inventory control in production management
- Compute the cash flow for a project
- Choose a project using decision theory based on the risk criterion.
- Apply the concepts of managerial economics in construction management

GECY111 PROGRAMMING USING MATLAB & SIMULINK

L	T	P	C
1	0	2	2

OBJECTIVES:

The aim of this course is to:

- Teach students how to mathematically model engineering systems
- Teach students how to use computer tools to solve the resulting mathematical models. The computer tool used is MATLAB and the focus will be on developing and solving models of problems encountered in engineering fields

MODULE I INTRODUCTION TO MATLAB AND DATA PRESENTATION 10

Introduction to MATLAB-Vectors, Matrices -Vector/Matrix Operations & Manipulation- Functions vs scripts- Making clear and compelling plots-Solving systems of linear equations numerically and symbolically.

Lab Experiments

1. Study of basic matrix operations and manipulations.
2. Numerical and symbolical solution of linear equations.

MODULE II ROOT FINDING AND MATLAB PLOT FUNCTION 10

Linearization and solving non-linear systems of equations- The Newton-Raphson method- Integers and rational numbers in different bases- Least squares regression -Curve fitting-Polynomial fitting and exponential fitting.

Lab Experiments

1. Solution of non linear equations using Newton-Raphson method.
2. Determination of polynomial fit and exponential fit for the given data.

MODULE III LINEAR AND NON-LINEAR DIFFERENTIAL EQUATIONS 13

Numerical integration and solving first order, ordinary differential equations (Euler's method and Runge-Kutta) - Use of ODE function in MATLAB- Converting second order and higher ODEs to systems of first order ODEs- Solving systems of higher order ODEs via Euler's method and Runge-Kutta) - Solving single and systems of non-linear differential equations by linearization-Use of the function ODE in MATLAB to solve differential equations - Plot Function –Saving & Painting Plots.

Lab Experiments

1. Solution of fourth order linear differential equations using
    a. Trapezoidal Rule

   b. Euler method
2. Solution of fourth order non-linear differential equations using
   a. Modified Euler method
   b. Runge – Kutta method

MODULE IV INTRODUCTION OF SIMULINK 12

Simulink & its relations to MATLAB – Modeling a Electrical Circuit- Modeling a fourth order differential equations- - Representing a model as a subsystem- Programme specific Simulink demos.

Lab Experiments

1. Solution of fourth order non-linear differential equations using simulink.
2. Programme specific experiment based on simulink.

Total Hours (Including Practicals): 45

REFERENCE:

1. Griffiths D V and Smith I M, “Numerical Methods for Engineers”, Blackwell, 1991.
2. Laurene Fausett, “Applied Numerical Analysis Using MATLAB”, Pearson 2008.
3. Moin P, “Fundamentals of Engineering Numerical Analysis”, Cambridge University Press, 2001.
4. Wilson HB, Turcotte LH, Advanced mathematics and mechanics applications using MATLAB”, CRC Press, 1997
5. Ke Chen, Peter Giblin and Alan Irving, “Mathematical Exploration with MATLAB”, Cambridge University Press, 1999.

OUTCOMES:

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

- Use Matlab as a convenient tool for solving a broad range of practical problems in engineering from simple models to real examples.
- Write programs using first principles without automatic use of built-in ones.
- Write programs for solving linear and nonlinear systems, including those arising from boundary value problems and integral equations, and for root-finding and interpolation, including piecewise approximations.
- Be fluent in exploring Matlab’s capabilities, such as using matrices as the fundamental data-storage unit, array manipulation, control flow, script and function m-files, function handles, graphical output.
- Make use of Maltab visual capabilities for all engineering applications.

- An ability to identify, formulate, and solve engineering problems. This will be accomplished by using MATLAB to simulate the solution to various problems in engineering fields

GECY112 JAVA PROGRAMMING

L	T	P	C
1	0	2	2

OBJECTIVES:

- To learn the fundamentals of Java programming such as data types, variables and arrays.
- To study the syntax and necessity of decision making and iterative statements.
- To create a class and invoke the methods.
- To instigate programming in overloading of methods.
- To emphasize the concept of packages.
- To learn the exception handling routines.

MODULE I INTRODUCTION TO JAVA PROGRAMMING 08

History and Evolution of Java – Overview of Java – Data types, variables and arrays – Operators – Control statements.

MODULE II METHODS AND CLASSES 07

Class fundamentals – Declaring objects – Methods – Constructors – Garbage collection – Overloading methods – Constructor overloading – Access control – Inheritance – Packages - Exception handling.

L: 15, P: 30, Total Hours: 15

REFERENCES:

1. Herbert Schildt, “Java The Complete Reference”, 9th Edition, Oracle Press, 2014, ISBN: 978007180855-2.
2. Nicholas S. Williams, **“**Professional Java for Web Applications: Featuring WebSockets, Spring Framework, JPA Hibernate and Spring Security (WROX)”, John Wiley & Sons, 2014, ISBN: 978111865651-8.
3. E Balagurusamy, “Programming with Java”, 5th Edition, Tata Mcgraw Hill, 2014.
4. Yashavant Kanetka**, “**Let Us Java”, 2nd Edition, BPB Publications, 2012**.**

OUTCOMES:

Students who complete this course will be able to

- Implement basic Java programming.
- Create a class and invoke methods for real world problems.

- Construct simple overloading of methods programs.
- Implement various types of inheritance concepts.
- Describe the access control mechanism.
- Handle exception thrown while implementing programming.

GECY113 PYTHON PROGRAMMING

L	T	P	C
1	0	2	2

OBJECTIVES:

- To learn the list and records of python programming.
- To study the control statements and string functions of python.
- To instigate the fundamental python programming.
- To emphasize GUI in python.
- To integrate python with embedded systems.
- To implement programs in python.

MODULE I INTRODUCTION TO PYTHON PROGRAMMING 08

Installation and environment set up – syntax used in python – variable types – operators – Loops – decision making – string functions - formatted files - GUI basics.

MODULE II EMBEDDED PROGRAMMING USING PYTHON 07

Web interface – system tools – script execution context - Motion-triggered LEDs – Python - Arduino prototyping-storing and plotting Arduino data-Remote home monitoring system.

L: 15, P: 30, Total Hours: 15

REFERENCES:

1. Nick Goddard, “Python Programming”, 2nd edition, ISBN: 1533337772, 2016.
2. Pratik Desai, “Python Programming for Arduino”, 1st edition, Packt publishing, 2015, ISBN: 9781783285938.
3. Mark Lutz, Learning Python: Powerful Object-Oriented Programming, 5th Edition, O'Reilly Media, 2013.
4. Richard H. Barnett, Sarah Cox, Larry O'Cull, “Embedded C Programming and the Atmel AVR”, 2nd edition, 2006.
5. Michael Barr, Anthony Massa, “Programming Embedded Systems”, 2nd Edition, O'Reilly Media, 2006.

OUTCOMES:

Students who complete this course will be able to

- Implement date and time function programming using python.

- Write formatted file programming.
- Construct simple python programs.
- Create web interface using python programming
- Develop embedded system with python programming.
- Build Arduino prototype using python programming.

GECY114 INTELLECTUAL PROPERTY RIGHTS (IPR)

L	T	P	C
1	0	0	1

OBJECTIVES:

- To study about Intellectual property rights and its need
- To explore the patent procedure and related issues

MODULE I INTRODUCTION 07

Introduction and the need for intellectual property right (IPR) – IPR in India – Genesis and Development – IPR in abroad – Important examples of IPR – Copyrights, Trademarks, Patents, Designs, Utility Models, Trade Secrets and Geographical Indications – Industrial Designs

MODULE II PATENT 08

Concept of Patent – Product / Process Patents & Terminology – Duration of Patents – Law and Policy Consideration Elements of Patentability –- Patentable Subject Matter – Procedure for Filing of Patent Application and types of Applications – Procedure for Opposition – Revocation of Patents – Working of Patents- Patent Agent – Qualification and Registration Procedure – Patent databases and information system – Preparation of patent documents – Process for examination of patent application- Patent infringement – Recent developments in patent system

Total Hours: 15

REFERENCES

1. B.L.Wadehra; Law Relating to Patents, Trade Marks, Copyright, Designs & Geographical Indications; Universal law Publishing Pvt. Ltd., India 2000
2. Ajit Parulekar and Sarita D' Souza, Indian Patents Law – Legal & Business Implications; Macmillan India ltd , 2006
3. P. Narayanan; Law of Copyright and Industrial Designs; Eastern law House, Delhi, 2010.
4. E. T. Lokganathan, Intellectual Property Rights (IPRs): TRIPS Agreement & Indian Laws Hardcover, 2012
5. Alka Chawla, P N Bhagwati , Law of Copyright Comparative Perspectives 1st Edition, LexisNexis, 2013
6. V. K. Ahuja, Law Relating to Intellectual Property Rights 2nd Edition, LexisNexis, 2nd Edition, 2013

7. Deborah E. Bouchoux, Intellectual Property: The Law of Trademarks, Copyrights, Patents, and Trade Secrets, 2015
8. Jatindra Kumar Das, Law of Copyright, PHI Learning, 2015

COURSE OUTCOMES:

Students should be able to

- Identify the various types of intellectual property and their value
- Apply the procedure to file a patent and to deal the related issues
- Search and extract relevant information from various intellectual database