MAR ATHANASIUS COLLEGE OF ENGINEERING (Autonomous)

Kothamangalam 686 666

Affiliated to APJ Abdul Kalam Technological University

Thiruvananthapuram

Master of Technology (M. Tech.) Curriculum - 2026

Power Electronics

COLLEGE VISION AND MISSION

VISION

Excellence in education through resource integration.

MISSION

The institution is committed to transform itself into a centre of excellence in Technical Education upholding the motto "Knowledge is Power."
This is to be achieved by imparting quality education to mould technically competent professionals with moral integrity, ethical values and social commitment, and by promoting innovative activities in the thrust areas emerging from time to time.

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS)

M.TECH CURRICULUM 2026

Electrical and Electronics Engineering

Power Electronics

PROGRAM OUTCOMES – PO

Outcomes are the attributes that are to be demonstrated by a graduate after completing the programme

PO1: An ability to independently carry out research/investigation and development work in engineering and allied streams

PO2: An ability to communicate effectively, write and present technical reports on complex engineering activities by interacting with the engineering fraternity and with society at large.

PO3: An ability to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher thanthe requirements in the appropriate bachelor program

PO4: An ability to apply stream knowledge to design or develop solutions for realworld problems by following the standards

PO5: An ability to identify, select and apply appropriate techniques, resources and state-of-the-art tool to model, analyse and solve practical engineering problems.

PO6: An ability to engage in life-long learning for the design and development of the stream related problems taking into consideration sustainability, societal, ethical and environmental aspects. Also to develop cognitive skills for project management and finance which focus on Industry and Entrepreneurship.

The departments conducting the M.Tech programme shall define their own PSOs, if required, and evaluation shall also be done for the same.

SEMESTER I

Slot	Course Code	Courses	Marks		L-T-P-S	Hours	Credit
			CIE	ESE			
A	M26EE1D101	Advanced Power Electronic Converters	60	40	3-0-3-6	6	5
B	M26EE1D102	Switched Mode Power Converters	60	40	3-0-3-6	6	5
C	M26EE1T103	System Theory	60	40	4-0-0-5	4	4
D	M26EE1E104A	Programme Elective 1	60	40	4-0-0-5	4	4
J	M26GE1R105	Research Methodology & IPR	60	40	2-0-0-4	2	2
Total			300	200		22	20

Teaching Assistance: 8 hours/week

Self-study- 26 Hrs

PROGRAMME ELECTIVE 1

Slot	Course Code	Courses	Marks		L-T-P-S	Hours	Credit
			CIE	ESE			
D	M26EE1E104A	Advanced Power Semiconductor Devices	60	40	4-0-0-5	4	4
D	M26EE1E104B	Power Quality, EMI Issues and Remedial Techniques	60	40	4-0-0-5	4	4
D	M26EE1E104C	Soft Computing Techniques for Power Electronic Applications	60	40	4-0-0-5	4	4
D	M26EE1E104D	Advanced Electric Drives	60	40	4-0-0-5	4	4

SEMESTER II

Slot	Course Code	Courses	Marks		L-T-P-S	Hours	Credit
			CIE	ESE			
A	M26EE1D201	Computational Optimization for Engineering Applications	60	40	3-0-3-6	6	5
B	M26EE1D202	Modelling and Control of Electric Drives	60	40	3-0-3-6	6	5
C	M26EE1E203A	Programme Elective 2	60	40	4-0-0-5	4	4
E	M26EE1S204	Electric Charging System for Electric Vehicles	60	40	4-0-0-5	4	4
G	M26EE1P205	Mini project	100		0-0-4-6	4	2
TOTAL			340	160		24	20

Teaching Assistance: 8 hours /week

Self-study- 28 Hrs

PROGRAMME ELECTIVE II

Slot	Course Code	Courses	Marks		L-T-P-S	Hours	Credit
			CIE	ESE			
D	M26EE1E203A	FACTS and Custom Power Devices	60	40	4-0-0-5	4	4
D	M26EE1E203B	Solar and Wind Power Conversion Systems	60	40	4-0-0-5	4	4
D	M26EE1E203C	Design of Power Electronic Systems	60	40	4-0-0-5	4	4
D	M26EE1E203D	Multilevel Inverters and Modulation Techniques	60	40	4-0-0-5	4	4

SEMESTER III

Slot	Course Code	Courses	Marks		L-T-P-S	Hours	Credit
			CIE	ESE			
A	M26EE1M301	*MOOC	To be completed successfully		--	--	2
K	M26EE1I302	Internship	50	50	--	--	10
P	M26EE1P303	Dissertation Phase 1	100	--	0-0-12-18	12	8
TOTAL			150	50		12	20

Teaching Assistance: 8 hours/week

*MOOC Course of minimum 8 weeks duration to be successfully completed before the end of fourth semester (starting from semester 1).

Internship - mandatory internship of minimum 16 weeks duration.

Dissertation Phase 1 may be undertaken either in the college or in the industry. Dissertation Phase 1 can be linked with internship. Students are expected to have the following skills: Technical Skills, Research Skills, Communication Skills, Critical Thinking Skills, and Problem Solving Skills.

SEMESTER IV

Slot	Course Code	Courses	Marks		L-T-P-S	Hours	Credit
			CIE	ESE			
P	M26EE1P401	Dissertation Phase II	100	100	0-0-24-26	24	20
TOTAL			100	100		24	20
Total credits in all four semesters							**80**

COURSE NUMBERING SCHEME

The course number consists of digits/alphabets. The pattern to be followed is

For General Courses - MYYBBXCSNN
For Elective Courses - MYYBBXCSNNA

- M: MASTERS
- YY: Last two digits of year of regulation
- BB: DEPARTMENT

Sl.No	Department	Course Prefix
01	Civil Engg	CE
02	Computer Science	CS

03	Electrical & Electronics	EE
04	Electronics & Communication	EC
05	Mechanical Engg	ME
06	Any	GE
07	External (Industry/NPTEL etc)	EX

- X : Specialization number
- C : Course Type

  T- Core Course

  E- Elective Course

  R- Research Methodology & IPR

  D- Lab integrated Course

  S- Industry Integrated Course

  I- Internship

  M- MOOC

  P- Project/Dissertation
- S : Semester of Study

  1. Semester 1
  2. Semester 2
  3. Semester 3
  4. Semester 4
- NN: Course sequence number
- A : Elective sequence number - A/B/C/D/E

It is illustrated below: Examples:

M26CE1T103 is a core course of first specialization offered by the Civil Department in semester 1

M26CE1D201 is a lab integrated core course of first specialization offered by the Civil Department in semester 2

M26GE1R106 is Research Methodology & IPR offered in semester 1offered by all Departments

M26EC1E104A is the first subject of Elective 1 of first specialization offered by the EC Department in semester 1.

EVALUATION PATTERN

(i) LAB INTEGRATED COURSES

Evaluation shall only be based on application, analysis or design based questions (for both internal and end semester examinations).

Continuous Internal Evaluation (CIE)	**: 60 marks**
Theory Evaluation	**: 30 marks**
Self-study (Course based task/Seminar/ Quiz/ Micro project)	: 10 marks
Test paper 1	: 10 marks
Test paper 2	: 10 marks
Lab Evaluation	**: 30 marks**
Lab work	: 10 marks
Final evaluation Test	: 20 marks
(Note: 50% of Module 1, 2 and 3 may be considered for each test)	
End Semester Examination (ESE)	**: 40marks**

The end semester examination should be conducted by the college. The time duration will be 2 Hrs and will contain 6 questions from first three modules, with minimum one question from each module of which student should answer any four. Each question can carry 10 marks and can have maximum 2 sub-divisions.

(ii) ELECTIVE COURSES/CORE COURSE

Evaluation shall only be based on application, analysis or design based questions (for both internal and end semester examinations).

Continuous Internal Evaluation	**: 60 marks**
Self-study (Seminar*)	: 10 marks
Course based task/Micro Project /Data collection and interpretation/Case study	: 20 marks
Test paper 1 (Module 1 and Module 2)	: 15 marks

Test paper 2 (Module 3 and Module 4) : 15 marks

*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course.

End Semester Examination (ESE) : 40 marks

The end semester examination will be conducted by the College. Total duration of the examination will be 2 Hrs and will contain 6 questions, with minimum one question from each module of which student should answer any four. Each question can carry 10 marks and can have maximum 2 sub-divisions.

(iii) RESEARCH METHODOLOGY & IPR

Continuous Internal Evaluation: 60 marks

Self-study (Preparing a review article based on peer reviewed original publications in the relevant discipline (minimum 10 publications shall be referred)) : 10 marks

Course based task/Seminar/Q uiz : 20 marks

Test paper 1 (Module 1 and Module 2) : 15 marks

Test paper 2 (Module 3 and Module 4) : 15 marks

End Semester Examination : 40 marks

The end semester examination should be conducted by the college. The time duration will be 2 Hrs and will contain 6 questions, with minimum one question from each module of which student should answer any four. Each question carries 10 marks.

(iv) INTERNSHIP

Internships are educational and career development opportunities, providing practical experience in a field or discipline. They are structured, short-term, supervised placements often focused around particular tasks or projects with defined time scales. An internship may be compensated or non-compensated by the organization providing the internship. The internship has to be meaningful and mutually beneficial to the intern and the organization. It is important that the objectives and the activities of the internship program are clearly defined and understood. The internship offers the students an opportunity to gain hands-on industrial or organizational exposure; to integrate the knowledge and skills acquired through the coursework; interact with professionals and other interns; and to improve their presentation, writing, and communication skills. Internship often acts as a gateway for final placement for many students.

A student shall opt for carrying out the Internship at an Industry/Research Organization or at

another institute of higher learning and repute (Academia). The organization for Internship shall be selected/decided by the students on their own with prior approval from the faculty advisor/respective PG Programme Coordinator/Guide/Supervisor. Every student shall be assigned an internship Supervisor/Guide at the beginning of the Internship. The training shall be related to their specialization after the second semester for a minimum duration of sixteen weeks. On completion of the course, the student is expected to be able to develop skills in facing and solving the problems experiencing in the related field.

Objectives

- Exposure to the industrial environment, which cannot be simulated in the classroom and hence creating competent professionals for the industry.
- Provide possible opportunities to learn understand and sharpen the real time technical / managerial skills required at the job.
- Exposure to the current technological developments relevant to the subject area of training.
- Create conducive conditions with quest for knowledge and its applicability on the job.
- Understand the social, environmental, economic and administrative considerations that influence the working environment.
- Expose students to the engineer's responsibilities and ethics.

Benefits of Internship Benefits to Students

- An opportunity to get hired by the Industry/ organization.
- Practical experience in an organizational setting & Industry environment.
- Excellent opportunity to see how the theoretical aspects learned in classes are integrated into the practical world. On-floor experience provides much more professional experience which is often worth more than classroom teaching.
- Helps them decide if the industry and the profession is the best career option to pursue.
- Opportunity to learn new skills and supplement knowledge.
- Opportunity to practice communication and teamwork skills.
- Opportunity to learn strategies like time management, multi-tasking etc in an industrial setup.
- Makes a valuable addition to their resume.
- Enhances their candidacy for higher education/placement.
- Creating network and social circle and developing relationships with industry people.
- Provides opportunity to evaluate the organization before committing to a full time position.

Benefits to the Institute

- Build industry academia relations.
- Makes the placement process easier.
- Improve institutional credibility & branding.
- Helps in retention of the students.
- Curriculum revision can be made based on feedback from Industry/ students.
- Improvement in teaching learning process.

Benefits to the Industry

- Availability of ready to contribute candidates for employment.
- Year round source of highly motivated pre-professionals.
- Students bring new perspectives to problem solving.
- Visibility of the organization is increased on campus.
- Quality candidate's availability for temporary or seasonal positions and projects.
- Freedom for industrial staff to pursue more creative projects.
- Availability of flexible, cost-effective workforce not requiring a long-term employer commitment.
- Proven, cost-effective way to recruit and evaluate potential employees.
- Enhancement of employer's image in the community by contributing to the educational enterprise.

Types of Internships

- Industry Internship with/without Stipend
- Govt / PSU Internship (BARC/Railway/ISRO etc)
- Internship with prominent education/research Institutes
- Internship with Incubation centres /Start-ups

Guidelines

- All the students need to go for internship for minimum duration of 16 weeks.
- Students can take mini projects, assignments, case studies by discussing it with concerned authority from industry and can work on it during internship.
- All students should compulsorily follow the rules and regulations as laid by industry.
- Every student should take prior permissions from concerned industrial authority if they want to use any drawings, photographs or any other document from industry.
- Student should follow all ethical practices and SOP of industry.
- Students have to take necessary health and safety precautions as laid bythe industry.

- Student should contact his /her Guide/Supervisor from college on weekly basis to communicate the progress.
- Each student has to maintain a diary/log book
- After completion of internship, students are required to submit
    - Report of work done
    - Internship certificate copy
    - Feedback from employer / internship mentor
    - Stipend proof (in case of paid internship).

Total Marks 100: The marks awarded for the Internship will be on the basis of (i) Evaluation done by the Industry (ii) Internal evaluation & Student's diary (iii) Internship Report and (iv) Comprehensive Viva Voce.

Continuous Internal Evaluation	**: 50 Marks**
Internal evaluation & Student's diary	:25 Marks
Evaluation done by the Industry	:25 Marks

Student's Diary/ Daily Log: The main purpose of writing daily diary is to cultivate the habit of documenting and to encourage the students to search for details. It develops the students' thought process and reasoning abilities. The students should record in the daily training diary the day to day account of the observations, impressions, information gathered and suggestions given, if any. It should contain the sketches & drawings related to the observations made by the students. The daily training diary should be signed after every day by the supervisor/ in charge of the section where the student has been working. The diary should also be shown to the Faculty Mentor visiting the industry from time to time and got ratified on the day of his visit. Student's diary wi **l** be evaluated on the basis of the following criteria:

- Regularity in maintenance of the diary
- Adequacy & quality of information recorded
- Drawings, design, sketches and data recorded
- Thought process and recording techniques used
- Organization of the information.

The format of student's diary

Name of the Organization/Section:

Name and Address of the Section Head:

Name and Address of the Supervisor:

Name and address of the student:

Internship Duration: From ..... To .....

Brief description about the nature of internship:

Day	Brief write up about the Activities carried out: Such as design, sketches, result observed, issues identified, data recorded, etc.
1	
2	
3	

Signature of Industry Supervisor *Signature of Section Head/HR Manager Office Seal*

Attendance Sheet

Month & Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	...
Month & Year																					
Month & Year																					

Name of Organization/Section

Name and Address of the Section Head:

Name and Address of the Supervisor:

Name and address of the student:

Internship Duration: From ..... To .....

Signature of Industry Supervisor *Signature of Section Head/HR Manager Office Seal*

Note:

- Student's Diary shall be submitted by the students along with attendance record and an evaluation sheet duly signed and stamped by the industry to the Institute immediately

after the completion of the training.

- Attendance Sheet should remain affixed in daily training diary. Do not remove or tear it off.
- Student shall sign in the attendance column. Do not mark 'P'.
- Holidays should be marked in red ink in the attendance column. Absent should be marked as 'A' in red ink.

Evaluation done by the Industry (Marks 25)

Format for Supervisor Evaluation of Intern

Student Name :_____ Date:_____ Supervisor Name :_____

_____ Designation:_____ Company/Organization :_____

_____

Internship Address: _____ Dates of Internship: From _____ To _____

Please evaluate intern by indicating the frequency with which you observed thefollowing parameters:

Parameters	**Marks** Rating (0-10 mark)
Behavior	
Performs in a dependable Manner	
Cooperates with coworkers and supervisor	
Shows interest in work	
Learns quickly	
Shows initiative	
Produces high quality work	
Accepts responsibility	
Accepts criticism	
Demonstrates organizational skills	
Uses technical knowledge and expertise	
Shows good judgment	
Demonstrates creativity/originality	
Analyzes problems effectively	
Is self-reliant	
Communicates well	
Writes effectively	
Has a professional attitude	
Is punctual	
Uses time effectively	

Evaluation marks : 20 Marks

Overall performance of student : 5 Marks

Intern (Tick one) : Needs improvement (0 - 1 mark) / Satisfactory (1-2 mark) / Good (2-3 mark) / Very Good (3-4 mark) / Excellent (4-5 mark)

Signature of Industry Supervisor *Signature of Section Head/HR Manager Office Seal*

End Semester Evaluation (External Evaluation) : 50 Marks

Internship Report : 25 Marks

Viva Voce : 25 Marks

Internship Report: After completion of the internship, the student should prepare a comprehensive report to indicate what he has observed and learnt in the training period and should be submitted to the faculty Supervisor. The student may contact Industrial Supervisor/ Faculty Mentor for assigning special topics and problems and should prepare the final report on the assigned topics. Daily diary will also help to a great extent in writing the industrial report since much of the information has alreadybeen incorporated by the student into the daily diary. The training report should be signed by the Internship Supervisor, Programme Coordinator and Faculty Mentor.

The Internship report (25 Marks) will be evaluated on the basis of following criteria:

- Originality
- Adequacy and purposeful write-up
- Organization, format, drawings, sketches, style, language etc.
- Variety and relevance of learning experience
- Practical applications, relationships with basic theory and concepts taught in the course

Viva Voce (25 Marks) will be done by a committee comprising Faculty Supervisor, PG Programme Coordinator and an external expert (from Industry or research/academic Institute). This committee will be evaluating the internship report also.

(v) INDUSTRY INTEGRATED COURSE

Engineering students frequently aspire to work in areas and domains that are key topics in the industry. There are concerns by recruiters that skill sets of engineering students did not match with the Industry requirements, especially in the field of latest topics. In response to their desires, the College has incorporated Industry integrated course in the curriculum.

The evaluation pattern for Industry based electives is as follows:

Continuous Internal Evaluation : 60 marks

Self-study (*Seminar)	:	10 marks
Course based task/Seminar/Data collection and interpretation/Case study	:	20 marks
Test paper 1 (Module 1 and Module 2)	:	15 marks
Test paper 2 (Module 3 and Module 4)	:	15 marks

End Semester Examination : 40 marks

The examination will be conducted by the College with the question paper provided by the Industry. The examination will be for 2 Hrs and will contain 6 questions, with minimum one question from each module of which student should answer any four. Each question can carry 10 marks. The valuation of the answer scripts shall be done by the expert in the Industry handling the course.

(vi) MOOC COURSES

The MOOC course shall be considered only if it is conducted by the agencies namely AICTE/NPTEL/SWAYAM or NITTTR. The MOOC course should have a minimum duration of 8 weeks and the content of the syllabus shall be enough for at least 40 hours of teaching. The course should have a proctored/offline end semester examination. The students can do the MOOC according to their convenience, but shall complete it before the end of fourth semester. The list of MOOC courses will be provided by the concerned BoS if at least 70% of the course content match with the area/stream of study. The course shall not be considered if its content has more than 50% of overlap with a core/elective course in the concerned discipline or with an open elective.

MOOC Course to be successfully completed before the end of fourth semester (starting from semester 1). A credit of 2 will be awarded to all students whoever successfully completes the MOOC course as per the evaluation pattern of the respective agency conducting the MOOC.

(vii) MINIPROJECT

Total marks : 100

Mini project can help to strengthen the understanding of student's fundamentals through application of theoretical concepts and to boost their skills and widen the horizon of their thinking. The ultimate aim of an engineering student is to resolve a problem by applying theoretical knowledge. Doing more projects increases problem- solving skills. The introduction of mini projects ensures preparedness of students to undertake dissertation. Students should identify a topic of interest in consultation with PG Programme Coordinator. Demonstrate the novelty of the project through the results and outputs. The progress of the mini project is evaluated based on three reviews, two interim reviews and a final review. A report is required at the end of the semester.

Interim evaluation: 60 (30 marks for each review), final evaluation by a Committee (will be evaluating the level of completion and demonstration of functionality/specifications, clarity of presentation, oral examination, work knowledge and involvement): 25, Report (the committee will be evaluating for the technical content, adequacy of references, templates followed and permitted plagiarism level is not more than 25%): 10, Supervisor/Guide: 5

(viii) DISSERTATION

Dissertation: All Students should carry out the dissertation in the college or can work either in any CSIR/Industrial R&D organization/any other reputed Institute which have facilities for dissertation work in the area proposed.

Dissertation outside the Institute: For doing dissertation outside the Institution, the following conditions are to be met:

- They have completed successfully the course work prescribed in the approved curriculum up to the second semester.
- The student has to get prior approval from the DLAC and CLAC.
- Facilities required for doing the dissertation shall be available in the Organization/Industry (A certificate stating the facilities available in the proposed organization and the time period for which the facilities shall be made available to the student, issued by a competent authority from the Organization/Industry shall be submitted by the student along with the application).
- They should have an external as well as an internal supervisor. The internal supervisor should belong to the parent institution and the external supervisor should be Scientists or Engineers from the Institution/Industry/ R&D organization with which the student is associated for doing the dissertation work. The external supervisor shall be with a minimum post graduate degree in the related area.
- The student has to furnish his /her monthly progress as well as attendance report signed by the external guide and submit the same to the concerned Internal guide.
- The external guide is to be preferably present during all the stages of evaluation of the dissertation.

Note1- Students availing this facility should continue as regular students of the College itself.

Internship leading to Dissertation: The M. Tech students who after completion of 16 weeks internship at some reputed organization are allowed to continue their work as dissertation for the third and fourth semester after getting approval from the DLAC. Such students shall make a brief presentation regarding the work they propose to carry out before the DLAC for a detailed scrutiny and to resolve its suitability for accepting it as an M.Tech dissertation. These students will be continuing as regular students of the Institute in third semester for carrying out all academic requirements as per the curriculum/regulation. However, they will be permitted to complete their dissertation in the Industry/Organization (where they have successfully completed their internship)

during fourth semester.

Dissertation as part of Employment: Students may be permitted to discontinue the programme and take up a job provided they have completed all the courses till second semester (FE status students are not permitted) prescribed in the approved curriculum. The dissertation work can be done during a later period either in the organization where they work if it has R & D facility, or in the Institute. Such students should submit application with details (copy of employment offer, plan of completion of their project etc.) to the Dean (PG) through HoD. When the students are planning to do the dissertation work in the organization with R & D facility where they are employed, they shall submit a separate application having following details:

- Name of R&D Organization/Industry
    - Name and designation of an external supervisor from the proposed Organization/Industry (Scientists or Engineers with a minimum post graduate degree in the related area) and his/her profile with consent
    - Name and designation of a faculty member of the Institute as internal supervisor with his/her consent
    - Letter from the competent authority from the Organization/Industry granting permission to do the dissertation
    - Details of the proposed work
    - Work plan of completion of project

DLAC will scrutinize the proposal and forward to the Dean (PG) through HoD for approval.

When students are doing dissertation work along with the job in the organization (with R & D facility) where they are employed, the dissertation work shall be completed in four semesters normally (two semesters of dissertation work along with the job may be considered as equivalent to one semester of dissertation work at the Institute). Extensions may be granted based on requests from the student and recommendation of the supervisors such that he/she will complete the M. Tech programme within four years from the date of admission as per the regulation. Method of evaluation and grading of the dissertation will be the same as in the case of regular students. MOOC can be completed as per the norms mentioned earlier.

Extended Submission for PG Thesis/Project: Extended submission may be permitted for students who have registered for the dissertation / thesis but require additional time for completion. The extended submission period shall be limited to a maximum of three months from the scheduled date of normal submission. Evaluation of theses submitted during the extended period shall be treated as part of the regular examination, and not as a supplementary examination. Extended submission shall be permitted only on the recommendation of the Project Supervisor. If the attendance requirements are not met, an 'FE' grade shall be awarded.

Mark Distribution:

Phase 1: Total marks: 100, only CIE
Phase 2: Total marks: 200, CIE = 100 and ESE = 100 marks

- If the student publishes the dissertation work in a recognized national/international conference or an indexed journal, 10 marks should be awarded.
- Final Evaluation (ESE) should be done by a three-member committee comprising of the Department Project coordinator, Guide and an External expert. The external expert shall be an academician or from industry
- If the quantum of work done by the candidate is found to be unsatisfactory, the evaluation committee may extend the duration of the project up to maximum of three months, giving reasons for this in writing to the student. Normally further extension will not be granted and there shall be no provision to register again for the project. A separate evaluation may be conducted for such candidates

(ix) TEACHING ASSISTANCESHIP (TA)

All M.Tech students irrespective of their category of admission, shall undertake TA duties for a minimum duration as per the curriculum. Being a TA, the student will get an excellent opportunity to improve their expertise in the technical content of the course, enhance communication skills, obtain a hands-on experience in handling the experiments in the laboratory and improve peer interactions.

The possible TA responsibilities include the following: facilitate a discussion section or tutorial for a theory/ course, facilitate to assist the students for a laboratorycourse, serve as a mentor for students, and act as the course web-master. TAs maybe required to attend the instructor's lecture regularly. A TA shall not be employed as a substitute instructor, where the effect is to relieve the instructor of his or her teaching responsibilities.

For the tutorial session:

(i) Meet the teacher and understand your responsibilities well in advance, attend the lectures of the course for which you are a tutor, work out the solutions for all the tutorial problems yourself, approach the teacher if you find any discrepancyor if you need help in solving the tutorial problems, use reference text books, beinnovative and express everything in English only.

(ii) Try to lead the students to the correct solutions by providing appropriate hints rather than solving the entire problem yourself, encourage questions from the students, lead the group to a discussion based on their questions, plan to ask them some questions be friendly and open with the students, simultaneously being firm with them.

(iii) Keep track of the progress of each student in your group, give a periodic feedback to the student about his/her progress, issue warnings if the student is consistently under-performing, report to the faculty if you find that a particular student is consistently underperforming, pay special attention to slow-learners and be open to the feedback and comments from the students and faculty.

(iv) After the tutorial session you may be required to grade the tutorials/assignments/tests. Make sure that you work out the solutions to the questions yourself, and compare it with the answer key, think and work out possible alternate solutions to the same question, understand the marking scheme from the teacher. Consult the teacher and make sure that you are not partial to some student/students

while grading. Follow basic ethics.

Handling a laboratory Session:

(i) Meet the faculty – in- charge a few days in advance of the actual lab class and get the details of the experiment, get clarifications from him/her regarding all aspects of the experiment and the expectations, prepare by reading about the theoretical background of the experiment, know the physical concepts involved in the experiment, go to the laboratory and check out the condition of the equipment/instrumentation, perform the laboratory experiment at least once one or two days before the actual laboratory class, familiarize with safety/ security aspects of the experiment / equipment/laboratory, prepare an instruction sheet for the experiment in consultation with the faculty, and keep sufficient copies ready for distribution to students for their reference.

(ii) Verify condition of the equipment/set up about 30 minutes before the students arrive in the class and be ready with the hand outs, make brief introductory remarks about the experiment, its importance, its relevance to the theory they have studied in the class, ask the students suitable questions to know there level of preparation for the experiment, discuss how to interpret results, ask them comment on the results.

(iii) Correct/evaluate/grade the submitted reports after receiving suitable instructions from the faculty in charge, continue to interact with students if they have any clarifications regarding any aspect of the laboratory session, including of course grading, Carefully observe instrument and human safety in laboratory class, Preparing simple questions for short oral quizzing during explanation of experiments enables active participation of students, facilitate attention, provides feedback and formative evaluation.

POINTS TO REMEMBER

1. Arrange an awareness programme to all M.Tech students on day 1 regarding the curriculum and the regulation.
2. The departments should prepare the list of MOOC courses suitable to their programmes and encourage the students to complete at the earliest.
3. Make a tie up with industries by the middle of semester for Industry Integrated Course. While choosing the course, it should be ensured that the programme is relevant and updated in that discipline. The Industry expert handling the course shall be a postgraduate degree holder. The evaluation procedure shall also be clearly explained to them.
4. Each department offering M.Tech programme should be careful in selecting the mini project in semester 2.
5. The departments should invite the Industries/research organizations during first semester and inform them about the mandatory 16 weeks internship that the students should undergo after their second semester. The possibility of doing their dissertation at the Industry shall also be explored. They should also be made aware about the evaluation procedure of the Internships. They may also be informed that it is possible to continue internship provided if it leads to their dissertation. Proposals may be collected from them for allottingto students according to their fields of interest.
6. Make sure that all internal evaluations and the end semester examinations to be conducted by the college are carried out as per the evaluation procedure listed in the curriculum. Any dilution from the prescribed procedure shall be viewed seriously.

7. Teaching assistance shall be assigned to all students as per the curriculum. However, a TA shall not be employed as a substitute instructor, where the effect is to relieve the instructor of his or her teaching responsibilities.
8. The possible TA responsibilities include the following: facilitate a discussion section or tutorial for a theory/ course, facilitate to assist the students for a laboratory course, serve as a mentor for students, and act as the course web-master.

MAR ATHANASIUS COLLEGE OF ENGINEERING

(Govt. Aided and Autonomous)

Kothamangalam-686666

M.TECH POWER ELECTRONICS

ELECTRICAL & ELECTRONICS ENGINEERING DEPARTMENT

SYLLABUS

2026

SEMESTER I

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M26EE1D101	ADVANCED POWER ELECTRONIC CONVERTERS	Discipline Core	3	0	3	6	5

Preamble:

This course provides a comprehensive overview of power electronic converters, its applications and hardware implementation. It aims to provide a strong foundation about gate drive circuits, controlled converters and PWM inverters. The content of the course helps to Identify and explore emerging applications of power electronic converters and its latest trends and advancements.

Prerequisite:

A strong understanding of electrical machines, Drives and control and power electronics at the UG level.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Analyze the operation and control of single-phase and three-phase controlled and PWM rectifiers. (Cognitive Knowledge Level: Analyze)
CO 2	Understand and analyze PWM techniques for voltage source inverters and the operation of multilevel inverters and matrix converters. (Cognitive Knowledge Level: Understand)
CO 3	Design FPGA-based digital systems using VHDL for power electronic converter control. (Cognitive Knowledge Level: Apply)
CO 4	Deign, simulate and implement various power electronic converters. (Cognitive Knowledge Level: Apply)

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	2	3	2	3	2
CO 2	3	2	3	3	3	2
CO 3	2	2	3	3	3	3
CO 4	3	2	3	2	2	2

Assessment Pattern

Bloom's Category	ADVANCED POWER ELECTRONIC CONVERTERS		
	Continuous Assessment Tests		End Semester Examination (% Marks)
	Test (%Marks)	Test 2 (% Marks)	
Remember			
Understand	30	30	30
Apply	20	20	20
Analyze	30	30	30
Evaluate	20	20	20
Create			

Mark distribution

Total Marks	CIA marks	ESE marks	ESE Duration
100	60	40	3 Hours

Continuous Internal Evaluation Pattern:

Evaluation shall only be based on application, analysis or design based questions (for both internal and end semester examinations).

Continuous Internal Evaluation (CIE) : 60 marks

Theory Evaluation : 30 marks

Self-study
(Course based task/Seminar/ Quiz/ Micro project) :10 marks
Test paper 1 :10 marks
Test paper 2 :10 marks

Lab Evaluation : 30 marks

Lab work : 10 marks
Final evaluation Test : 20 marks
(Note: 50% of Module 1, 2 and 3 may be considered for each test)

End Semester Examination (ESE) : 40marks

The end semester examination should be conducted by the college. The time duration will be 2 Hrs and will contain 6 questions from the first three modules, with a minimum one question from each module of which student should answer any four. Each question can carry 10marks and can have a maximum of 2sub-divisions.

SYLLABUS

MODULE 1 (8 hours)

Controlled Rectifiers

Controlled Rectifiers - Three-phase semi & full converters – waveforms and analysis – inversion, twelve-pulse converter - need for multi-pulse converters, circuit configuration and operation, comparison with six- pulse converter, single-phase dual converter fed SEDC motor drive – circulating & non-circulating current operation, comparison.

PWM Rectifiers (Active Front-End Converters)

Limitations of phase-controlled rectifiers, single phase PWM rectifier - circuit topology and operating principle, single phase PWM rectifier- circuit configuration, control schemes – hysteresis and PWM control.

MODULE 2 (12 hours)

PWM Inverters

Review of voltage source inverter (VSI)- sinusoidal PWM – linear & over modulation, bipolar & unipolar PWM, DC link current, selection of filter capacitor, effect of blanking time, common mode voltage, third harmonic injection PWM, space vector modulation, current source inverter - current control.

Multilevel inverters

Diode-clamped multilevel inverter, Flying-capacitors multilevel inverter, cascaded multilevel inverter, PWM for multilevel inverters.

Matrix converters

Types, principle, switches for matrix converters, 3-phase matrix converter, Venturini control method.

MODULE 3 (12 hours)

Gate Drive Circuits for Power Devices

Overview of power switching devices, gate drive requirements, gate drive circuits for power MOSFETs and IGBTs, design considerations, power losses, thermal modelling, heat sink selection criteria.

FPGA-Based System Design

Introduction, VHDL programming, test bench, design of basic combinational, sequential and finite state machines, realization using any FPGA board (altera/xilinx/altium/efinix etc.)

Case studies of power electronic converter control using any C28x microcontroller and/ FPGA board.

MODULE 4 (30 hours)

Simulation Experiments:

1. Simulation of single phase and three phase full converter with RL and RLE loads using Matlab Simulink.
2. Simulation of PWM rectifier.
3. Simulation of single-phase dual converter fed SEDC motor drive – circulating & non-circulating current operation.
4. Simulation of three phase inverters with sine triangle and space vector modulation.
5. Simulation multilevel inverters with diode clamped and cascaded multilevel inverters

Hardware Experiments:

1. Design and set up a gate drive circuit using opto coupler TLP250H IC and SG3525 IC.
2. Design and set up a half bridge square wave inverter circuit using SG3525 IC/ IR2111 IC.
3. Design and set up a full bridge square wave inverter circuit using SG3525 IC/ IR2111 IC.
4. Sine PWM generation using FPGA/TMS320F28335.
5. Three phase sine PWM generation using FPGA/TMS320F28335

Reference Books

1. N. Mohan, T. M. Undeland, and W. P. Robbins, Power Electronics: Converters, Applications, and Design, 3rd ed. Hoboken, NJ, USA: John Wiley & Sons, 2007.
2. G. K. Dubey, Fundamentals of Electrical Drives, 2nd ed. New Delhi, India: Narosa Publishing House, 2001.
3. M. H. Rashid, Power Electronics: Circuits, Devices, and Applications, 3rd ed. Upper Saddle River, NJ, USA: Prentice Hall, 2004.
4. W. Shepherd and L. Zhang, Power Converter Circuits. New York, NY, USA: Marcel Dekker, Inc., 2004.
5. D. Grahame Holmes, Thomas A Lipo, Pulse Width Modulation for Power converters- Principles and Practice, John Wiley and sons, 2003.
6. R. W. Erickson and D. Maksimović, Fundamentals of Power Electronics, 2nd ed. New York, NY, USA: Springer, 2013.
7. B. W. Williams, Principles and Elements of Power Electronics: Devices, Drivers, Applications, and Passive Components. Glasgow, U.K. Barry W. Williams, 2006.
8. F. L. Luo and H. Ye, Power Electronics: Advanced Conversion Technologies. Boca Raton, FL, USA: CRC Press, 2010.

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COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1	**8**
1.1	3-phase full converters	1
1.2	Twelve-pulse converter	1
1.3	Single-phase dual converter fed SEDC motor drive	1
1.4	Circulating & non-circulating current operation	1
1.5	Single phase and 3-phase PWM rectifier	2
1.6	Control schemes – hysteresis and PWM control	2
	Module 2	**12**
2.1	Need for PWM - Voltage Source Inverter (VSI)- sinusoidal PWM	1
2.2	Bipolar & unipolar voltage switching, Linear & over modulation	1

2.3	DC link current - selection of filter capacitor	1
2.4	Effect of blanking time on voltage in PWM inverter	1
2.5	Common mode voltage - Third harmonic injection PWM - Space Vector Modulation	1
2.6	Multilevel inverters – Diode-clamped multilevel inverter	1
2.7	Flying-capacitors multilevel inverter	1
2.8	Cascaded multilevel inverter	1
2.9	PWM for multilevel inverters	1
2.10	Matrix converter –types- principle – switches for matrix converters	2
2.11	3-phase matrix converter - Venturini control method.	1
	Module 3	**12**
3.1	Overview of power switching devices, gate drive requirements.	1
3.2	Gate drive circuits of MOSFET, IGBT.	1
3.3	Design considerations, power losses, thermal modelling.	1
3.4	Power dissipation and selection of heat sink.	
3.5	FPGA Based System Design- Introduction	1
3.6	VHDL programming- test bench -	2
3.7	Design of basic combinational, sequential and finite state machines	2
3.8	Realization using any FPGA board (altera/xilinx/altium/efinix etc.)	2
3.9	Case studies of power electronic converter control using any C28x microcontroller and/ FPGA board.	2
	Module 4	**30**
4.1	Simulation of single phase and three phase half converters with RL and RLE loads using Matlab Simulink.	3
4.2	Simulation of single phase and three phase full converter with RL and RLE loads using Matlab Simulink.	3
4.3	Simulation of single-phase dual converter fed SEDC motor drive – circulating & non-circulating current operation.	3
4.4	Simulation of three phase inverters with sine triangle and space vector modulation.	3
4.5	Simulation multilevel inverters with diode clamped and cascaded multilevel inverters	3
4.6	Design and set up a gate drive circuit using optocoupler TLP250H IC and SG3525 IC.	3
4.7	Design and set up a half bridge square wave inverter circuit using SG3525 IC/ IR2111 IC.	3
4.8	Design and set up a full bridge square wave inverter circuit using SG3525 IC/ IR2111 IC.	3
4.9	Sine PWM generation using FPGA/TMS320F28335.	3
4.10	Three phase sine PWM generation using FPGA/TMS320F28335.	3

Model Question Paper

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Reg No.:_____

Name:_____

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIRST SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2026

Course Code: M26EE1D101

Course Name: ADVANCED POWER ELECTRONIC CONVERTERS

Max. Marks:40 Duration: 2 hours

Answer any four questions. Each question carries 10 marks.

1. With the circuit diagram of a single-phase dual converter fed separately excited DC drive in circulating current mode, obtain the relationship between firing angles.
2. a) Derive an expression for RMS output voltage of a single-phase semi converter with RL load. (5 marks)

   b) Obtain the firing angle for the above converter with an input sinusoidal voltage of 230V RMS and average output voltage of 193V. (5 marks)
3. a) With the circuit diagram and waveforms of the IGBT based current source inverter illustrate the working. (5 marks)

   b) Explain the control strategies of PWM rectifier. (5 marks)
4. Along with circuit diagram and waveforms discuss the working of cascaded multilevel inverter.
5. Design and develop a digital gate drive circuit to trigger a MOSFET IRF540 suitable for a step-up converter with an input voltage of 24V, output voltage of 48V. Also explain the operation of the gate drive circuit.
6. a) Explain why FPGA is preferred in some applications when compared to microcontrollers (5 marks)

   b) Write a VHDL code to insert a 1us delay for a pulse input at the rising edge. Explain how this could be used for dead time generation. (5 marks)

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M26EE1D102	SWITCHED MODE POWER CONVERTERS	Programme Core	3	0	3	6	5

Preamble: This course provides an understanding of switched mode power converters, its applications and hardware implementation. It aims to provide a strong foundation about modeling and control of switched mode power converters and also introduces microcontroller-based control systems, covering peripheral interfacing and integration with simulation environments. This course equips students with both analytical and hands-on skills required for designing efficient and reliable power electronic systems in industrial and research applications.

Prerequisite: Basic Knowledge in Power Electronics and Power Electronics Lab at UG Level.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Analyze the operation of basic DC–DC non-isolated converters and to design auxiliary circuits such as snubbers and heat sinks. (Cognitive level-Analyse)
CO 2	Analyze the operation of isolated DC–DC converters and address sub-harmonic instability using slope compensation. (Cognitive level-Analyse)
CO 3	Apply state-space averaging techniques to model DC–DC converters and learn to interface C2000 microcontrollers with MATLAB for analysis, simulation, and real-time control applications. (Cognitive level-Apply)
CO 4	Design, simulate and implement various power electronic converters and drives and to build laboratory reports as a document that clearly communicate experimental information. (Cognitive level-Apply)

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	1	1	2	1	1
CO 2	3	1	1	2	1	1
CO 3	3	1	1	2	1	1
CO 4	1	1	1	1	1	3

Assessment Pattern

	SWITCHED MODE POWER CONVERTERS		
Bloom's Category	**Continuous Internal Evaluation Tests**		**End Semester Examination (%Marks)**
	Test 1 (%Marks)	**Test 2 (%Marks)**	
Remember			
Understand	30	30	30
Apply	30	30	30
Analyse	20	20	20
Evaluate	20	20	20
Create			

Mark distribution

Total Marks	**CIE marks**	**ESE marks**	**ESE Duration**
100	60	40	2 Hours

Continuous Internal Evaluation Pattern:

Theory Evaluation **: 30 marks**

Self-study (Course based task/Seminar/ Quiz/ Micro project) :10 marks

Test paper 1 :10 marks

Test paper 2 :10 marks

Lab Evaluation **: 30 marks**

Lab work : 10 marks

Final evaluation Test : 20 marks

(Note: 50% of Module 1, 2 and 3 may be considered for each test)

End Semester Examination Pattern:

The end semester examination should be conducted by the college. The time duration will be 2 hrs and will contain 6 questions from the first three modules, with minimum one question from each module of which student should answer any four. Each question can carry 10 marks and can have a maximum of 2 sub-divisions.

SYLLABUS

MODULE 1 (12 hours)

DC-DC non-isolated converters

Review-Buck, Boost, Buck-Boost converters in continuous and discontinuous conduction mode - analysis and design; CUK and SEPIC converters - operation in continuous conduction mode; analysis and design, Comparison of converters; Selection of components; Switching and conduction losses-numerical Problems Design of snubber and heat sink, Flux Imbalance issues - Design of Magnetics-Volt-Sec Balance Inductor Design -Transformer Design.

MODULE 2 (8 hours)

Isolated DC-DC converters

Push-Pull Converter, Half and Full Bridge Converters- Basic Operation and Waveforms. Forward Converter- continuous conduction mode only, Flyback Converter- continuous conduction mode only-numerical Problems, Study of a typical Voltage Mode PWM Control IC-SG3525.

Current Mode Control

Advantages, Current Mode vs. Voltage Mode, Hysteresis control, one cycle control, sub-harmonic instability- Slope compensation. Study of a typical Current Mode PWM Control IC - UC3842.

MODULE 3 (16 hours)

Modelling and Control of second order switched mode power converters

State space averaging and linearization, Small signal approximation and circuit averaged model; Voltage Mode control – Transfer Functions, Stability, Design of compensators.

Introduction to high performance Microcontroller based system design

C2000 microcontrollers- overview of architecture and peripherals, hardware details, firmware environment - GPIO, SCI, ADC, PWM, Encoder. Interfacing with Matlab.

MODULE 4 (24 hours)

List of experiments

Simulation Experiments

1) Performance Analysis of Buck and Boost Converters.
2) Performance Analysis of Forward and Push Pull converters

3) Speed control of chopper fed DC motor drive in continuous conduction mode.
4) Design, state variable model, bode plot, compensator, stability and closed control for a second order DC- DC converter.
5) High frequency inductor/Transformer design.

Hardware Experiments -

1) Design and Implementation of Buck and Boost converters using discrete IC-SG352.
2) H/W - Speed control of chopper fed DC motor drive.
3) Design and realization of switching regulator-based charging circuit for lead acid/ lithium –ion batteries.
4) Design and Implementation of Buck, Boost and Buck-Boost converters using DSP processor TMS320F28335.
5) Fixed duty ratio PWM generation using DSP processor TMS320F28335.

Reference Books

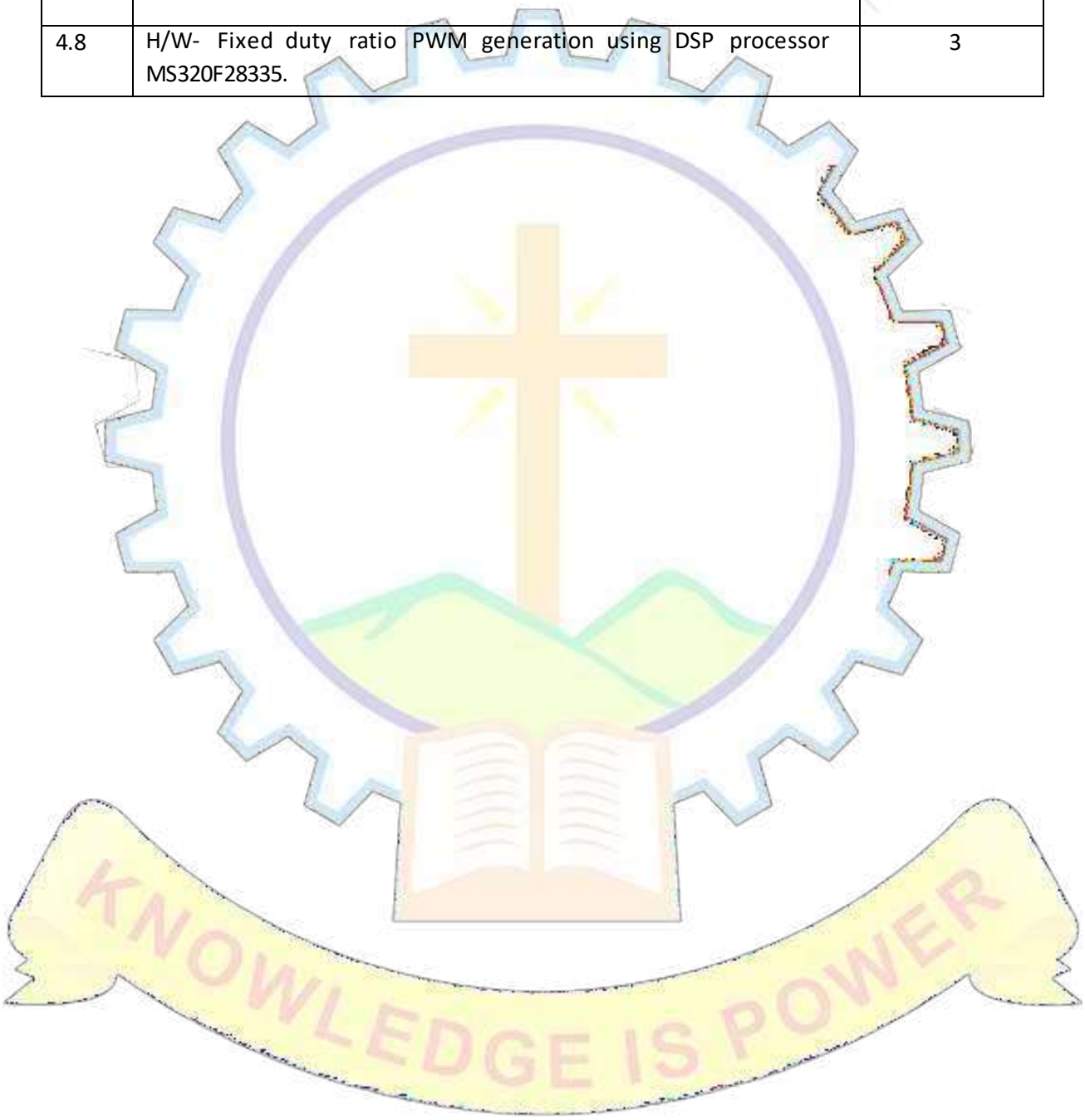
1. Mohan, Undeland, Robbins, Power Electronics – Converters, Applications and Design, Wiley-India, 3rd Ed., 2007.
2. Daniel W. Hart, *Power Electronics,* Tata McGraw-Hill, 1st Ed., 2011.
3. Robert. W. Ericson, Fundamentals of Power Electronics, Springer, 3rd Ed., 2020.
4. Abraham I Pressman, Keith Billings, and Taylor Morey, Switching Power Supply Design, McGrawHill, 3rd Ed., 2009.
5. L. Umanand, *Power Electronics: Essentials and Applications*. Wiley India 1st Ed., 2009
6. Muhammad Ali Mazidi, Rolind D. Mckinlay, Danny Causey, PIC microcontroller and Embedded Systems – using assembly and C for PIC18, Pearson, 1st Ed., 2013.
7. Mattia Rossi, Nicola Toscani, Marco Mauri, Francesco Castelli Dezza, Introduction to Microcontroller Programming for Power Electronics Control Applications Coding with MATLAB and Simulink, CRC Press, 1st Ed., 2022.
8. Prof. V. Ramanarayanan, Course Material on Switch Mode Power Conversion, Electrical Department, IISc, Bangalore, 2006.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1: DC-DC non-isolated converters	**12**
1.1	Buck converter in continuous and discontinuous conduction Analysis and Design.	2
1.2	Boost converter in continuous and discontinuous conduction Analysis and Design.	2
1.3	Buck-Boost converter in continuous and discontinuous conduction Analysis and Design.	2
1.4	CUK and SEPIC converters- operation in continuous conduction Mode.	2

1.5	Comparison of converters, Selection of components, switching and conduction losses.	1
1.6	Design of Snubber and heat sink.	1
1.7	Flux Imbalance issues - Design of Magnetics-Volt-Sec Balance Inductor	2
	Design -Transformer Design.	
	Module 2: Isolated DC-DC converters	**8**
2.1	Push-Pull Converter - Basic Operation, Waveforms.	1
2.2	Half and Full Bridge Converters- Basic Operation, Waveforms.	1
2.3	Forward Converter -continuous conduction mode only.	1
2.4	Flyback Converter - continuous conduction mode only.	1
2.5	Study of a typical Voltage Mode PWM Control IC-SG3525.	1
2.6	Current Mode Control: Advantages, Current Mode vs. Voltage Mode, Hysteresis control.	1
2.7	One cycle control, sub-harmonic instability- Slope compensation.	1
2.8	Study of a typical Current Mode PWM Control IC - UC3842.	1
	Module 3: Modelling and Control of second order switched mode power converters	**16**
3.1	State space averaging and linearization.	2
3.2	Small signal approximation and circuit averaged model.	2
3.3	Voltage Mode control – Transfer Functions.	2
3.4	Stability, Design of compensators.	1
3.5	C2000 microcontrollers- overview of architecture and peripherals.	2
3.6	GPIO Peripheral- hardware details, firmware Environment, Analog to Digital Converter Peripheral -operating principle, hardware details, firmware environment.	2
3.7	Serial Communication Interface Peripheral (SCI)- hardware details, firmware environment.	1
3.8	PWM- operating principle, hardware details, Generation of PWM signals, firmware environment.	2
3.9	Encoder- operating principle of Incremental encoders, hardware details.	1
3.10	Interfacing with Matlab.	1
	Module 4	**24**
4.1	Performance Analysis of Buck and Boost Converters. Performance Analysis of Forward and Push Pull converters.	3
4.2	Speed control of chopper fed DC motor drive in continuous conduction mode.	3
4.3	Design, state variable model, bode plot, compensator, stability and closed control for a second order DC- DC converter. High frequency inductor/Transformer design.	3
4.4	H/W-Design and Implementation of Buck and Boost converters using discrete IC-SG352.	3

4.5	H/W - Speed control of chopper fed DC motor drive.	3
4.6	H/W- Design and realization of switching regulator-based charging circuit for lead acid/ lithium- ion batteries.	3
4.7	H/W- Design and Implementation of Buck and Boost converters using DSP processor TMS320F28335.	3
4.8	H/W- Fixed duty ratio PWM generation using DSP processor MS320F28335.	3



Model Question Paper

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Reg No.:_____

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MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIRST SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2026

Course Code: M26EE1D102

Course Name: SWITCHED MODE POWER CONVERTERS

Max. Marks:40 Duration: 2 hours

Answer any four questions. Each question carries 10 marks.

1. a. For an ideal boost converter, derive the expression for voltage gain in terms of circuit parameters during continuous conduction mode (CCM) of operation. (6 marks)

   b. With a neat circuit diagram explain the operation of a buck converter. (4 marks)

2. a. The cuk converter of has parameters Vs -12V, D -0.6, L1 -200 µH, L2 -100 µH, C1= C2 = 2µF, and R- 12Ω, and the switching frequency is 250 kHz. Determine (a) the output voltage, the average and the peak-to-peak variation of the currents in L1 and L2. (6 marks)

   b. What are the considerations for the design of optimum RC- snubber components? (4 marks)

3. a. The Forward converter has the following parameters: Vs =48 V, R = 10Ω, Lx =0.4 mH, Lm =5 mH, C =100 µF, f =35 kHz, N1/N2 =1.5, N1/N3 = 1, D =0.4. Determine the output voltage, the maximum and minimum currents in Lx, and the output voltage ripple. Assume all components are ideal. (6 marks)

   b. With figures, explain the working of Half bridge isolated DC-DC converter. (4 marks)

4. a The Flyback converter has parameters Vs =5V, D =0.5, $N1/N2$ =0.4, R =20 Ω, L_m =15 µH, and C=10 µF, and the switching frequency is 200 kHz Determine (a) the output voltage, (b) the average value of inductor current, and (c) the output voltage ripple. (6 marks)

   b Explain the basic operating principle of one cycle control. (4 marks)

5 a. For a Boost converter derive the transfer function for voltage gain. (6 marks)
b. Derive the large signal model of buck converter. (4 marks)

6. a Describe the PWM module of C28X and explain how a 10KHz, 25% duty cycle PWM can be generated using embedded coder/C-program. (6 marks)

b. Describe the PWM module of C28X microcontroller. (4 marks)

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M26EE1T103	SYSTEM THEORY	Programme Core	4	0	0	5	4

Preamble: System theory is a fundamental discipline within the realm of applied mathematics and engineering. This course provides students with a comprehensive understanding of key concepts in linear algebra and the study of linear systems including the system representation in state-space, stability analysis, and controller design techniques. This course lays a solid foundation for students pursuing careers in control engineering, applied mathematics, and related disciplines, providing them with the tools necessary to excel in a rapidly evolving technological landscape.

Prerequisite: Basic knowledge of engineering mathematics and linear control systems at UG level.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Apply linear algebraic techniques to solve linear systems and the vector space properties such as subspaces, basis, dimension, and kernel to create mathematical models for engineering and scientific applications. (Cognitive Knowledge Level: Apply)
CO 2	Apply the principles of state-space modelling to represent dynamic systems in different canonical forms and analyze the solutions of linear systems using state equations (Cognitive Knowledge Level: Apply)
CO 3	Analyze the dynamic behavior of systems and assess their controllability and observability for stable operation and understand the Kalman decomposition theorem (Cognitive Knowledge Level: Apply)
CO 4	Develop proficiency in designing feedback controllers, state observers and combined observer controller configuration (Cognitive Knowledge Level: Analyze)

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	1	3	3	3	3	2
CO 2	1	3	3	3	3	2
CO 3	1	3	3	3	3	2
CO 4	1	3	3	3	3	2

Evaluation Pattern

Bloom's Category	SYSTEM THEORY		
	Continuous Internal Evaluation Tests		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	-	-	-
Understand	30	30	30
Apply	50	50	50
Analyse	20	20	20
Evaluate	-	-	-
Create	-	-	-

Mark distribution

Total Marks	CIE marks	ESE marks	ESE Duration
100	60	40	2 Hours

Continuous Internal Evaluation Pattern:

Self-study (Seminar*) :10 marks

Course based task//Micro Project/Data collection and interpretation/Case study :20 marks

Test paper 1 (Module 1 and Module 2) :15 marks

Test paper 2 (Module 3 and Module 4) :15 marks

*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course.

End Semester Examination Pattern: The end semester examination will be conducted by the college. Total duration of the examination will be 2 Hrs and will contain 6 questions, with minimum one question from each module of which student should answer any four. Each question can carry 10 marks and can have maximum 2 sub-divisions.

SYLLABUS

Module I (14 hours)

System of linear equations

Row reduction and Echelon forms, existence and uniqueness of solution of linear systems, homogeneous and non-homogeneous systems, dimension of the solution space associated with the system of linear equations. Matrix representations: Eigenvalues and Eigen vectors, Eigenspaces, algebraic and geometric multiplicity, similarity, diagonalization, rank of the quadratic form .

Vector Spaces

Definition of vector space, sub spaces, null space, column space, linear independence and dependence, linear span, basis, dimension, dual spaces, kernel.

Module II (11 hours)

State space modelling of dynamical systems

State space models of linear systems, solution to LTI and LTV systems, solutions to homogeneous and non-homogeneous cases, computation of matrix exponentials. Equivalent state space models - similarity transformations, canonical forms. Numerical problems.

Module III (11 hours)

System Analysis

Stability - Eigenvalue conditions for stability, Eigen values and system poles.
Controllability and observability - controllability matrix, controllability grammians, observability matrix, observability grammians, reachability and constructability, controllable subspaces, controllable and uncontrollable modes, reachable and observable subspaces, Kalman decomposition. Numerical problems
Case study: State space modelling and analysis of DC-DC converters

Module IV (9 hours)

Design of state feedback controllers and Observers

State feedback controller for regulator and servo systems, state observer design - full order and reduced order, separation principle, combined observer controller configuration. Numerical problems.

Reference Books

1. Bhaskar Dasgupta, *Applied Mathematical Methods.* Pearson, 1st ed.,2010
2. Chi-Tsong Chen, *Linear system theory and design.* Oxford, 4th ed., 2013
3. Ogata K., *Modern Control Engineering*. Prentice Hall of India, 5th ed., 2010.

4. Gopal M, *Modern Control System Theory*. New Age Publishers, 2nd ed., 1984
5. Erwin Kreyszig, *Advanced Engineering Mathematics*. Wiley International EditionPress, 9th ed.,1996
6. Arfken, Weber and Harris, *Mathematical Methods for Physicists A comprehensive guide*. Elsevier, 7th ed., 2013
7. Thomas Kailath, *Linear Systems*, Prentice-Hall,2nd ed., 1980
8. Nagarath I. J. and Gopal M., *Control System Engineering*. New Age Publishers, 5th ed., 2007
9. Gilbert Strang, *Linear Algebra and its application.* Pearson, 5th ed.,2016
10. David C Lay, *Linear Algebra and its application.* Pearson, 6th ed., 2016

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1: System of linear equations	**14**
1.1	Row reduction and echelon forms , pivot position	1
1.2	Existence and uniqueness of solution of linear systems	1
1.3	Homogeneous and non-homogeneous systems	1
1.4	Dimension of the solution space associated with the system of linear equations	1
1.5	Eigenvalues, eigenvectors, eigenspaces	1
1.7	Algebraic multiplicity, geometric multiplicity	1
1.8	Similarity, diagonalizability	1
1.9	Rank of the quadratic form	1
1.10	**Vector Spaces**	
1.11	Spaces and subspaces	1
1.12	Linear combination of vectors, linear span	1
1.13	Column space, null space, spanning sets	1
1.14	Linear independence and dependance	1
1.14	Basis- basis for null A & column A, dimension and rank	1
1.15	Dual spaces, kernel	1
	Module 2 : State space modelling of dynamic systems	**11**
2.1	State space models of linear systems	1
2.2	Solution to LTI systems, numerical problems	2
2.3	Solution to LTV systems	1
2.4	Solutions to homogeneous cases, numerical problems	1
2.5	Solutions to non-homogeneous cases, numerical problems	2
2.6	Computation of matrix exponentials	1
2.7	Equivalent state space models - similarity transformations, numerical problems	2
2.8	Transformation of state model to canonical form, numerical problems	1

	Module 3 : System Analysis	**11**
3.1	Stability - Eigenvalue conditions for stability, Eigen values and system poles.	2
3.2	Controllability - controllability matrix, numerical problems	1
3.3	Controllability grammians, numerical problems	2
3.4	Observability - observability matrix, numerical problems	1
3.5	Observability grammians	1
3.6	Reachability and constructability	1
3.7	Controllable subspaces, controllable and uncontrollable modes	1
3.8	Reachable and observable subspaces	1
3.9	Kalman decomposition, numerical problems	1
	Module 4: Design of state feedback controllers and Observers	**9**
4.1	State feedback controller design for regulator systems, numerical problems	2
4.2	State feedback controller design for servo systems, numerical problems	2
4.3	Design of full order state observer, numerical problems	2
4.4	Design of reduced order state observer	1
4.5	Separation principle	1
4.6	Combined observer controller configuration	1

Model Question Paper

QP CODE: Pages: 2

Reg No.:_____

Name:_____

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM
FIRST SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2026

Course Code: M26EE1T103

Course Name: SYSTEM THEORY

Max. Marks:40 Duration: 2 hours

Answer any four questions. Each question carries 10 marks.

1. a. Determine geometric multiplicity, algebraic multiplicity and basis for the eigen space of each eigen value

   A= $\begin{bmatrix} 1 & 3 & 3 \\ -3 & -5 & -3 \\ 3 & 3 & 1 \end{bmatrix}$ (6 marks)

   b. Determine h and k such that system has a) no solution b) a unique solution and c) many solutions for the system of equations $x_1 + h\,x_2 = 2$, $4\,x_1 + 8\,x_2 = k$. (4 marks)

2. a. Let $\mathbf{A} = \begin{bmatrix} -2 \\ 1 \\ 1 \end{bmatrix}$, $\mathbf{B} = \begin{bmatrix} 6 \\ -5 \\ -1 \end{bmatrix}$, $\mathbf{C} = \begin{bmatrix} -8 \\ 5 \\ 3 \end{bmatrix}$ and $\mathbf{D} = \begin{bmatrix} -4 \\ -5 \\ -1 \end{bmatrix}$

   Do A , B , C and D span R3. Justify your answer? (6 marks)

   b. Show that the set of vectors V1 = (0,1,-2) , V2 = (1,-1,1) and V3 = (1,2,1) are linearly independent? (4 marks)

3. a) Find the matrix representation for the linear transformation T: R2→R2 defined by T(a,b) = (11a+3b , -5a-5b) with respect to the standard basis

   (i) B = {(1,0) , (0,1)}

   (ii) B = {(1,1) , (1,-1)} (7 marks)

   b) Examine the following transformation and prove T is linear

   T: $R^2 \to R^3$ $defined$ by $T(a,b) = (a+b, a-b, b)$. (3 marks)

4. a) The state equation and initial condition vector of a linear time-invariant system are given below. Determine the solution of state equation.

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix} = \begin{bmatrix}1 & 0\\ 1 & 1\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}; x_0 = \begin{bmatrix}1\\ 0\end{bmatrix}$$ (5 marks)

b) The state model of the system represented by

$$X=\begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ -1 & -3 & -3\end{bmatrix}x\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}+\begin{bmatrix}1\\ 0\\ 0\end{bmatrix}u\,(t) \quad \text{and} \quad Y=\begin{bmatrix}1 & 2 & 1\end{bmatrix}x(t)$$

Check whether the given system is completely state controllable or not (5 marks)

5. Consider the system represented by

$$X=\begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ 0 & -2 & -3\end{bmatrix}x\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}+\begin{bmatrix}0\\ 0\\ 10\end{bmatrix}u\,(t) \quad \text{and} \quad Y=\begin{bmatrix}0 & 0 & 1\end{bmatrix}x(t)$$

Compute the state feedback gain matrix so that the control law u = -kx , places the closed loop poles at -2, $-1\pm j$.

6. a. What is the significance of Kalman decomposition? Transform the state space equation into a canonical form using Kalman decomposition. (6 marks)

b. The state model of the system represented by

$$X=\begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ -1 & -3 & -3\end{bmatrix}x\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}+\begin{bmatrix}1\\ 0\\ 0\end{bmatrix}u\,(t) \quad \text{and} \quad Y=\begin{bmatrix}1 & 2 & 1\end{bmatrix}x(t)$$

Check whether the given system is completely state observable or not (4 marks)

PROGRAM ELECTIVE I

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M26EE1E104A	ADVANCED POWER SEMICONDUCTOR DEVICES	Elective	4	0	0	5	4

Preamble: Power semiconductor devices are recognized as a key component for all power electronic systems. This course explores the underlying physics and electrical characteristics of power semiconductor devices and includes the study of basic silicon devices and the new generation wide band gap devices. After the completion of the course, students will be able to select suitable power semiconductor devices and design gate drive & protection circuits.

Prerequisite: Solid foundation spanning material science, basic electronics, and electromagnetic theory

Course Outcomes: After the completion of the course the student will be able to

CO 1	Integrate device modeling, SPICE simulation, and gate drive with isolation and sensing to ensure safe, efficient power semiconductor performance. (Cognitive knowledge level: Analyse)
CO 2	Analyse the characteristics and operational features of selected power semiconductor devices, including the properties of wide bandgap devices for power electronic applications (Cognitive knowledge level: Analyse)
CO 3	Familiarize the students with advanced power electronic devices for different applications (Cognitive knowledge level: Understand)
CO 4	Design gate driver and protection circuits for power electronic switching devices. (Cognitive knowledge level: Apply)

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	2	3	2	2	1
CO 2	2	2	3	2	3	1
CO 3	2	3	3	3	3	2
CO 4	2	2	3	1	3	1

Evaluation Pattern

Bloom's Category	ADVANCED POWER SEMICONDUCTOR DEVICES		
	Continuous Internal Evaluation Tests		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% Marks)	
Remember	-	-	-
Understand	20	20	20
Apply	40	40	40
Analyse	40	40	40
Evaluate	-	-	-
Create	-	-	-

Mark distribution

Total Marks	CIE marks	ESE marks	ESE Duration
100	60	40	2 Hours

Continuous Internal Evaluation

Self-study (Seminar*) :10 marks

Course based task//Micro Project/Data collection

and interpretation/Case tudy :20 marks

Test paper 1 (Module 1 and Module 2) :15 marks

Test paper 2 (Module 3 and Module 4) :15 marks

*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course.

End Semester Examination

The examination will be conducted by the college with the question paper provided by the industry. The examination will be for 2 hrs. and will contain 6 questions, with minimum one question from each module of which student should answer any four. Each question can carry 10 marks. The valuation of the answer scripts shall be done by the expert in the industry handling the course.

SYLLABUS

MODULE 1 (9 hours)

Power Semiconductors in converters

Static models, switch energy losses, heat transfer models for power semiconductors, snubbers, SPICE model. Power semiconductor switches: Gate drives, isolation, sensors for power electronicsswitches, nonelectrical sensing

MODULE 2 (10 hours)

Voltage-controlled Devices and Wide band-gap devices

Voltage-controlled Devices: Power MOSFETs and IGBTs basic device physics, principle of operation, construction, types, static and switching characteristics.
Wide band-gap devices introduction, advantages over silicon devices, properties of wide band-gap devices, power density of wide bandgap devices, comparison, applications Silicon carbide(SiC),power diodes, advantages, features, properties, comparison with Si power diodes - SiC Schottky diode, advantages

MODULE 3 (12 hours)

Silicon Carbide and Hetero Junction Field Effect Transistor

Silicon Carbide BJT – structure, operation, static and dynamic Characteristics. Silicon Carbide MOSFET, Planar Power MOSFETs, Trench Gate Power MOSFETs – structure, static and dynamic characteristics Silicon Carbide IGBT: n-channel asymmetric structure, optimized n-channel asymmetric structure, p-Channel asymmetric structure- blocking characteristics, on-state voltage drop, turn-off characteristics, switching energy, losses, maximum operating frequency Gallium Nitride devices, vertical power Hetero Junction Field Effect Transistor (HFETs), Lateral Power Hetero Junction Field Effect Transistor (HFETs), High Electron Mobility Transistors (HEMT) - static and dynamic characteristics

MODULE 4 (9 hours)

Gate drive and Protection Circuits

Gate drive circuits for transistors, MOSFET, IGBT, SiC MOSFET and IGBT and GaN devices, challenges and design, necessity of isolation, pulse transformer, optocoupler, overvoltage, over currentandgate protection- turn-on and turn-off snubber circuit design.
Power modules- typical internal structure, design challenges, features, design for reliability enhancement intelligent power modules (IPM)- features, study of typical power modules and IPM.

References

1. B. W. Williams, *Power Electronics- Devices, Drivers, Applications and passive components*, Macmillan, 2nd Ed., 2005.
2. B. Jayant Baliga, *Fundamentals of Power Semiconductor devices*, 2nd Ed., Springer, 2019.
3. Francesco Iannuzzo, *Modern Power Electronic Devices*, *Physics, Applications, and Reliability*, Institution of Engineering & Technology (IET),3rd Ed., 2020.
4. Mohan, Undeland and Robins, *Power Electronics- Concepts, Applications and Design*, John Wiley and sons, Singapore, 1st Ed., 2000.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1: Power Switching Devices	**9**
1.1	Switching device state, static models	1
1.2	Switch energy losses - general analysis of losses, losses during commutation	1
1.3	Heat transfer models for power semiconductor	1
1.4	Snubbers - introduction, lossy turn off, turn on,combined and lossless	1
1.5	SPICE model - diode, thyristor, BJT, MOSFET	1
1.6	Gate drives - voltage controlled gates, current controlled gates, pulsed gate drives, isolation	2
1.7	Sensors for power electronic switches- resistive, integrating, nonelectrical sensing	2
	Module 2: Voltage-controlled Devices and Wide band-gap devices	**10**
2.1	Voltage-controlled Devices: Power MOSFETs and IGBTs- basic device physics- principle of operation	2
2.2	Construction, types, static and switching characteristics	2
2.3	Wide band-gap devices – Introduction, advantages over silicon devices	2
2.4	properties of wide band-gap devices,	2
2.5	power density of widebandgap devices, comparison, applications	2
	Module 3: Silicon Carbide and Hetero Junction Field Effect Transistor	**12**
3.1	Silicon carbide (SiC) power diodes- Advantages- features- properties- comparison with Si power diodes- SiC Schottky diode- advantages	2
3.2	Silicon Carbide BJT – Structure – Operation – Static and Dynamic Characteristics	1
3.3	Silicon Carbide MOSFET – Planar Power MOSFETs – Trench Gate Power MOSFETs – Structure – static and dynamic characteristics	2

3.4	Silicon Carbide IGBT: n-Channel Asymmetric Structure - Optimized n Channel asymmetric structure	2
3.5	P-channel asymmetric structure- blocking characteristics- On- state voltage Drop - turn-off characteristics	1
3.6	Switching energy - losses- maximum operating frequency	1
3.7	Gallium nitride devices –Vertical Power Hetero Junction Field Effect Transistor (HFETs) – Lateral Power Hetero Junction Field Effect Transistor (HFETs)	2
3.8	High Electron Mobility Transistors (HEMT) - Static and dynamic characteristics	1
	Module 4: Gate drive and Protection Circuits	**9**
4.1	Gate drive and Protection Circuits: Gate drive circuits for transistors, MOSFET, IGBT, SiC MOSFET and IGBT and GaN devices–challenges and design	2
4.2	Necessity of isolation- pulse transformer- optocoupler overvoltage, over current and gate protection	1
4.3	Turn-on and turn-off snubber circuit design	1
4.4	Power modules- typical internal structure- design challengesfeatures- design for reliability enhancement	2
4.5	Intelligent power modules (IPM)- features	1
4.6	Study of typical power modules and IPMS	2

Model Question Paper

QP CODE: Pages: 1

Reg No.:_____

Name:_____

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIRST SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2026

Course Code: M26EE1E104A

Course Name: ADVANCED POWER SEMICONDUCTOR DEVICES

Max. Marks:40 Duration: 2 hours

Answer any five questions. Each question carries 12 marks.

1. (a) Explain static models of power semiconductor devices and analyze their significance in determining conduction characteristics. (4 marks)
   (b) Explain the design and role of snubber circuits in protecting power electronic switches. (6 marks)
2. (a) What are wide band gap devices and what are its advantages over silicon devices? (4 marks)
   (b) Explain the structure, operation, and static & dynamic characteristics of Silicon Carbide BJT. (6 marks)
3. (a) Explain the switching characteristics of P channel MOSFET. (4 marks)
   (b) Describe the turn-off characteristics, switching energy, and losses in Silicon Carbide IGBT and comment on maximum operating frequency. (6 marks)
4. (a) Explain the differences between Silicon Carbide and Gallium Nitride Transistors in terms of gate drive design. (4 marks)
   (b) Explain the structure, operation, and static & dynamic characteristics of Vertical and Lateral HFETs in Gallium Nitride devices. (6 marks)
5. (a) Explain the design of IGBT driver circuit with over current protection. (4 marks)
   (b) Explain the static and switching characteristics of GaN switching devices. (6 marks)
6. (a) Explain the purpose of turn-on and turn-off snubber circuits. (4 marks)
   (b) Explain the structure, features, and reliability considerations of power modules. (6 marks)

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M26EE1E104B	POWER QUALITY, EMI ISSUES AND REMEDIAL TECHNIQUES	Elective	4	0	0	5	4

Preamble: The course attempts to impart knowledge about power quality issues, and mitigation techniques. It also covers the EMI issues, measurement and Electromagnetic compatibility (EMC) compliance in power electronics and electronic circuits. This course will equip students to analyse power system harmonics and examine its effect on performance parameters. Students are trained to select suitable custom power devices and design using suitable control strategies.

Prerequisite: Fundamentals of Power Electronics

Course Outcomes: After the completion of the course the student will be able to

CO 1	Classify and illustrate power quality issues, and analyze power system harmonics along with their effects on performance parameters (Cognitive knowledge level: Analyse)
CO 2	Select suitable custom power devices and design using suitable control strategies like PQ theory (Cognitive knowledge level: Apply)
CO 3	Identify the EMI causes, measurement and mitigation methods (Cognitive knowledge level: Understand, Evaluate)
CO 4	Select suitable PCB layout and decoupling to reduce EMI (Cognitive knowledge level: Apply, Analyse)

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	1	3	2	2	2
CO 2	2	1	3	2	2	2
CO 3	2	1	3	2	2	2
CO 4	2	1	3	2	2	2

Evaluation Pattern

	POWER QUALITY, EMI ISSUES AND REMEDIAL TECHNIQUES		
Bloom's Category	**Continuous Internal Evaluation Tests**		**End Semester Examination (% Marks)**
	Test 1 (% Marks)	**Test 2 (% Marks)**	
Understand	60	60	60
Apply	40	40	40
Analyse	-		
Evaluate	-	-	-
Create	-	-	-

Mark distribution

Total Marks	CIE marks	ESE marks	ESE Duration
100	60	40	3 Hours

Continuous Internal Evaluation

Self-study (Seminar*) :10 marks

Course based task//Micro Project/Data collection and interpretation/Case tudy :20 marks

Test paper 1 (Module 1and Module 2) :15 marks

Test paper 2 (Module 3 and Module 4) :15 marks

*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course.

End Semester Examination

The examination will be conducted by the college with the question paper provided by the industry. The examination will be for 2 hrs. and will contain 6 questions, with minimum one question fromeach module of which studentshould answer any four. Each question can carry 10 marks. The valuation of the answer scripts shall be done by the expert in the industry handling the course.

SYLLABUS

MODULE 1 (12 hours)

Power Quality Issues and Power System Harmonics

Power Quality (PQ) issues- causes and effects- power frequency disturbances-voltagesag,swell,flicker, IEEE 1453 standard- voltage imbalance and low frequency noise- remedies- isolation transformers-voltage regulators and uninterruptible power supplies-voltage tolerance criteria- power system transient model- transients due to atmospheric conditions, load switching, interruption of fault currents, capacitor bank switching- neutral voltage swing.

Power system harmonics- causes of current and voltage harmonics- individual and total harmonic distortion- harmonic signature of different loads- lighting- adjustable speed drives, single phase-controlled converters, switch mode power supplies, battery chargers and arc furnaces- effect of harmonics on power system devices- IEEE519 and IEEE1159 harmonic standards, harmonic current mitigation-harmonic cancellation- filters- power quality instrumentation and measurements- case studies.

MODULE 2 (10 hours)

Power Quality Mitigation

Overview of mitigation methods- shunt active filters and series active filters- single-phase two- wire, three-phase three-wire, and three-phase four-wire- principle of operation- case studies-DSTATCOM-mitigation of poor power factor, unbalanced currents, and increased neutral current- VSI basedthree-phase three-wire and four wire DSTATCOM- principle of operation and control - VSI basedthree-phase three-wire Dynamic voltage restorer- unified power quality conditioner.

MODULE 3 (10 hours)

Electromagnetic Interference

Electromagnetic Interferences (EMI) and Electro Magnetic Compatibility (EMC) regulations- IEC61800-3 - CISPR25- conducted and radiated emission mechanisms in power electronic circuits - typical noise path- methods of reducing interference- Capacitive and inductive coupling Shielding of cables and transformers - ground loops- testing of conducted EMI- LISN- Near and far fields, characteristic and wave impedances, shielding effectiveness- conducted emissions- power line filters-common mode choke - design- magnetic field emissions- system design for EMC.

MODULE 4 (8 hours)

Power Supply Decoupling, PCB Design and ESD Protection in Electronic Systems

Power supply decoupling- transient power supply current and load current- Fourier spectrum decoupling capacitors- target impedance- effect of decoupling on radiated emissions- PCB layout considerations- PCB to chassis ground connection- multilayer boards, mixed-signal. PCB layout considerations- mixed-signal power distribution- Electrostatic Discharge (ESD) - Static generation, human body model, ESD protection in equipment design, Transient and Surge Protection Devices

Reference

1. Alexander Kusko, Marc T. Thompson, *Power Quality in Electrical Systems*, McGrawHill, 4th edition 2007.
2. Francois Costa et al, *Electromagnetic compatibility in Power Electronics*, Wiley Iste, 2nd edition, 2014.
3. Bhim Singh, Ambrish Chandra and Kamal Al-Haddad, *Power Quality Problems and Mitigation Techniques*, Wiley, 5th edition 2015.
4. Henry W.Ott, *Electromagnetic Compatibility Engineering*, Wiley Interscience,2009.
5. H.W. Whittington, *Switched Mode Power Supplies: Design and Construction*, Wiley, 2nd edition, 1997.
6. A Ghosh, G. Ledwich, *Power Quality Enhancement Using Custom Power Devices*, Kluwer Academic, 2002.
7. Jos Arrillaga, Neville R Watson, *Power system harmonics*, Wiley, 2nd edition 1995

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1 : Power Quality Issues and Power System Harmonics	**12**
1.1	Power Quality (PQ) issues- causes and effects	1
1.2	Power frequency disturbances-voltage sag, swell, flicker, voltage imbalance and low frequency noise- remedies	1
1.3	Isolation transformers- voltage regulators and uninterruptible power supplies	1
1.4	Voltage tolerance criteria- power system transient model transients due to atmospheric conditions, load switching	1
1.5	Interruption of fault currents, capacitor bank switching neutral voltage swing	2
1.6	Power system harmonics- causes of current and voltage harmonics	1
1.7	Individual and total harmonic distortion- harmonic signature of different loads- lighting- adjustable speed drives, single phase controlled converters, switch mode power supplies, battery chargers and arc furnaces	1
1.8	Effect of harmonics on power system devices- IEEE519 harmonic standards	1
1.9	Harmonic current mitigation-harmonic cancellation- filters	1
1.10	Power quality instrumentation and measurements- case studies	2
	Module 2: Power Quality Mitigation	**10**
2.1	Overview of mitigation methods- shunt active filters and seriesactive filters	1
2.2	Single-phase two-wire, three-phase three-wire, and threephasefour wire- principle of operation- case studies	2
2.3	D-STATCOM- mitigation of poor power factor	1
2.4	Unbalanced currents and increased neutral current	2
2.5	VSI based three-phase three-wire and four wire DSTATCOM principle of operation and control	2
2.6	VSI based three-phase three-wire dynamic voltage restorer	1
2.7	Unified power quality conditioner	1
	Module3: Electromagnetic Interference	**10**
3.1	Electromagnetic Interferences (EMI) and Electromagnetic Compatibility (EMC) regulations- IEC61800-3- CISPR25	**1**
3.2	Conducted and radiated emission mechanisms in power electronic circuits-	1
3.3	Typical noise path- methods of reducing interference	2
3.4	Capacitive and inductive coupling	1
3.5	Shielding of cables and transformers- ground loops	1
3.6	Testing of conducted EMI- LISN	1
3.7	Near and far fields, characteristic and wave impedances, shielding effectiveness- conducted emissions	1
3.8	Power line filters-common Mode Choke - design- magnetic field emissions- system design for EMC	2

	Module 4: Power Supply Decoupling, PCB Design and ESD	**8**
	Protection in Electronic Systems	
4.1	Power supply decoupling- transient power supply current and load current-fourier spectrum- decoupling capacitors	2
4.2	Target impedance- effect of decoupling on radiated emissions	1
4.3	PCB layout considerations- PCB to chassis ground connection- multilayer boards, mixed-signal PCB layout considerations	2
4.4	Mixed-signal power distribution	1
4.5	Electrostatic Discharge (ESD) - Static generation, human body model, ESD protection in equipment design	1
4.6	Transient and Surge Protection Devices	1

Model Question Paper

QP CODE: Pages: 1

Reg No.:_____

Name:_____

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIRST SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2026

Course Code: M26EE1E104B

Course Name: POWER QUALITY, EMI ISSUES AND REMEDIAL TECHNIQUES

Max. Marks:40 Duration: 2 hours

Answer any five questions. Each question carries 12 marks.

1. (a) Explain the harmonics in single phase-controlled converters. (4 marks)
   (b) Explain various power quality (PQ) issues and their causes and effects in power system. (6 marks)
2. (a) Explain the principle of operation of a shunt active power filter. (4 marks)
   (b) Describe the principle of operation and any one control scheme of DVR. (6 marks)
3. (a) How does D-STATCOM improve power factor? (4 marks)
   (b) Explain VSI-based three-phase three-wire D-STATCOM operation and control. (6 marks)
4. (a) What are conducted and radiated emissions? (4 marks)
   (b) Explain EMC regulations with reference to IEC 61800-3 and CISPR 25. (6 marks)
5. (a) List the key requirements of EMC regulations in industrial drives. (4 marks)
   (b) Draw the circuit diagram of a forward converter operating at 50kHz, power being drawn from 230V, 50Hz mains. Identify the possible conducted noise emission sources and explain the means to reduce EMI. (6 marks)
6. (a) What are the advantages of using multilayer PCBs for digital circuits? Explain mechanism of cross talk in multilayer PCBs and methods to reduce cross talk. (4 marks)
   (b) Explain PCB layout considerations to reduce conducted noise. (6 marks)

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M26EE1E104C	SOFT COMPUTING TECHNIQUES FOR POWER ELECTRONIC APPLICATIONS	Elective	4	0	0	5	4

Preamble: This course provides the fundamentals of soft computing techniques for power electronic applications. It covers fuzzy logic systems, artificial neural networks, genetic algorithm and hybrid systems. This course will equip the students with the soft computing techniques necessary for engineering systems for various applications.

Prerequisite: B. Tech level Power Electronics.

Course Outcomes: After the completion of the course, the student will be able to

CO 1	Design and analyze fuzzy logic controllers for engineering applications. (Cognitive knowledge level : Analyze)
CO 2	Apply artificial neural networks with back propagation algorithm for implementing power electronic circuits. (Cognitive knowledge level : Apply)
CO 3	Analyze power electronic circuits with different neural network configurations and algorithms. (Cognitive knowledge level : Analyze)
CO 4	Apply genetic algorithm and hybrid intelligent techniques to solve complex engineering problems. (Cognitive Knowledge Level : Apply)

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	1	3	2	1	2
CO 2	2	1	3	2	1	2
CO 3	2	1	3	2	1	2
CO 4	2	1	3	2	1	2

Assessment Pattern

Bloom's Category	SOFT COMPUTING TECHNIQUES FOR POWER ELECTRONIC APPLICATIONS		
	Continuous Internal Evaluation Tests		End Semester Examination (% Marks)
	Test 1 (% Marks)	Test 2 (% Marks)	
Remember	-	-	-
Understand	-	-	-
Apply	40	40	40
Analyse	60	60	60
Evaluate	-	-	
Create	-	-	-

Mark distribution

Total Marks	CIE marks	ESE marks	ESE Duration
100	60	40	2 Hours

Continuous Internal Evaluation Pattern:

Self-study (Seminar*) :10 marks

Course based task/ Micro project /

Data collection and interpretation/ Case study :20 marks

Test paper 1 (Module 1 and Module 2) :15 marks

Test paper 2 (Module 3 and Module 4) :15 marks

*Seminar shall be conducted in additional hours with topics in recent technologies.

End Semester Examination Pattern: The end semester examination will be conducted by the college. It will contain 6 questions, with minimum one question from each module of which student shall answer any four. Each question carries 10 marks and can have maximum two sub-divisions. Total duration of the examination will be 2 hrs.

SYLLABUS

MODULE 1 (10 hours)

Fuzzy Systems

Introduction to Fuzzy Logic (FL), classical sets and fuzzy sets - classical relations and fuzzy relations –properties of fuzzy sets and fuzzy relations – fuzzy compositions, max-min and max product compositions - membership functions - defuzzification – weighted average method, centre of sums method, centroid method - Mamdani and Sugeno type- fuzzy rule base and approximate reasoning - introduction to fuzzy decision making, special forms of fuzzy logic models –fuzzy inference systems - fuzzy logic controllers for engineering applications - case studies – fuzzy logic controller for a power electronic converter – fuzzy logic inverter controller in solar power generation.

MODULE 2 (10 hours)

Artificial Neural Networks (ANN)

Biological neurons and its working. ann models - types of activation function - introduction to network architectures - Multi Layer Feed Forward Network (MLFFN) - Radial Basis Function Network (RBFN) - Recurrent Neural Network (RNN)- back propagation neural networks – back propagation algorithm, local minimum, network paralysis, derivation of weight update equations - case studies related to power electronic applications – ANN for maximum power point tracking (MPPT) control for wind energy conversion systems.

MODULE 3 (10 hours)

Other types of ANN

Kohonen neural network – initialization of weight vectors - hamming neural network–maxnet - Hopfield neural network- energy states, stationary points, design of Hopfield net - bi-directional associative memory - Adaptive Resonance Theory(ART) neural networks - cluster discovery - case studies – ANN applications in power electronics and motor drives.

MODULE 4 (10 hours)

Genetic Algorithm(GA)

Basic genetic algorithm framework and different GA architectures, GA operators – Encoding - Crossover – Selection – Mutation, Solving single objective optimization problems using GAs, multi objective GA, case studies – optimization of power electronic circuits using genetic algorithm.

Hybrid Systems

Adaptive Neuro Fuzzy Inference System (ANFIS), neuro–genetic, fuzzy-genetic systems.Coactive neuro-fuzzy modelling - generalized ANFIS. Fuzzy neuron - Fuzzy back propagation architecture

- case studies related to power electronic applications.

References

1. Teresa Orlowska, Blaabjerg and Rodriguez, *Advanced and Intelligent Control in Power Electronics and Drives*, Springer, 1st ed.,2014.
2. Marcian Cirstea, Andrei Dinu, Malcolm McCormick, Jeen Ghee Khor, *Neural and Fuzzy Logic Control of Drives and Power Systems*, Newness, 2nd ed.,2001.
3. S. N. Sivanandam & S. N. Deepa, *Principles of Soft Computing*, 2nd edition, Wiley India, 2nd ed., 2008.
4. Ross, T. J., Fuzzy Logic with Engineering Applications, John Wiley & Sons, Hoboken, NJ, 4th ed., 2016.
5. S. Rajasekaran, G. A. Vijayalakshmi Pai, *Neural Networks, Fuzzy Logic and Genetic Algorithm, Synthesis and Applications*, PHI Learning Pvt. Ltd., 2nd ed .,2017.
6. J. S. R. Jang, C.T. Sun and E. Mizutani, *Neuro-Fuzzy and Soft Computing*, Pearson Education, 1st ed.,2004.
7. J. M. Zurada, *Introduction to Artificial Neural Systems*, Jaico Publishers, 1st ed., 1992.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1 : Fuzzy Systems	**10**
1.1	Introduction to Fuzzy Logic (FL), Classical Sets and Fuzzy Sets.	1
1.2	Classical Relations and Fuzzy Relations, Membership Functions	1
1.3	Properties of fuzzy sets	1
1.4	Fuzzy compositions	1
1.5	Defuzzification – weighted average, centre of sums, centroid	2
1.6	Mamdani and Sugeno models	1
1.7	Fuzzy Rule Base and Approximate Reasoning	1
1.8	Introduction to Fuzzy Decision Making, Special forms of fuzzy logic models.	1
1.9	Fuzzy logic controllers for Engineering applications, Case studies.	1
	Module 2: Artificial Neural Networks (ANN)	**10**
2.1	Artificial Neural Networks (ANN): Biological neurons and its working, ANN models.	2
2.2	Types of activation function - Introduction to network architectures.	1
2.3	Multi Layer Feed Forward Network (MLFFN).	1
2.4	Radial Basis Function Network (RBFN).	1
2.5	Recurrent Neural Network (RNN).	1
2.6	Case studies related to power electronic applications.	1
2.7	Back propagation neural networks.	1
2.8	Local minimum, network paralysis.	1
2.9	Derivation of weight update equations.	1
	Module 3 : Other types of ANN	**10**
3.1	Kohonen neural network.	1

3.2	Initialization of weight vectors.	1
3.3	Hamming neural network.	1
3.4	Maxnet.	1
3.5	Hopfield neural network.	1
3.6	Energy states, stationary points.	1
3.7	Design of Hopfield network.	1
3.8	Bi- directional associative memory.	1
3.9	Adaptive Resonance Theory (ART) neural networks.	1
3.10	Case studies related to power electronic applications.	1
	Module 4 : Genetic Algorithm(GA)	**10**
4.1	Basic genetic algorithm (GA) framework and different GA architectures.	1
4.2	GA operators: encoding, crossover, selection, mutation.	1
4.3	Solving single objective optimization problems using GA.	1
4.4	Multi objective GA	1
4.5	Case studies related to power electronic applications.	1
4.6	Hybrid Systems: Adaptive Neuro Fuzzy Inference System (ANFIS).	1
4.7	Neuro –genetic, Fuzzy-genetic systems.	1
4.8	Coactive neuro-fuzzy modelling.	1
4.9	Fuzzy neuron - Fuzzy back propagation architecture	1
4.10	Case studies related to power electronic applications.	1

Model Question Paper

QP CODE: Pages: 1

Reg No.:_____

Name:_____

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIRST SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2026

Course Code: M26EE1E104C

Course Name: SOFT COMPUTING TECHNIQUES FOR POWER ELECTRONIC APPLICATIONS

Max. Marks:40 Duration: 2 hours

Answer any four questions. Each question carries 10 marks.

1. Consider the fuzzy sets
   A = {0.3/1 + 0.6/2 + 0.2/3 + 0.5/4}
   B = {0.2/1 + 0.5/2 + 0.7/3 + 0.9/4}
   Prove De Morgan's theorem.

2. Describe the Back propagation network configuration, write the weight update equations and explain the training process in detail.

3. Describe how Bidirectional associative memory is implemented using recurrent neural network.

4. Compute the weight matrix for Hopfield net for the following fundamental memories. Also compute the energy states for these fundamental memories.
   ξ1= [1 -1 -1 1 -1], ξ2= [-1 1 1 -1 1], ξ3= [1 1 -1 1 -1], ξ4= [-1 -1 1 -1 1]

5. Evaluate the role of the following genetic operators in finding solution for optimization problems. a) Selection b) crossover c) encoding and d) Mutation

6. Draw the ANFIS architecture of Mamdani's model and describe the features.

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M26EE1E104D	ADVANCED ELECTRIC DRIVES	Elective	4	0	0	5	4

Preamble: This course aims to equip students with a comprehensive understanding of the operational principles, control strategies, and performance characteristics of modern electric motor drives. The content spans from traditional DC and AC motor control using power electronic converters to advanced drive systems for special motors like SRMs, BLDC, and PMSM machines. After completion of this course, students will be able to select appropriate power electronic converters and motors for specific industrial needs while applying diverse speed control schemes to effectively manage various electric drives.

Prerequisite: Basic courses on Electrical Machines and Power Electronics

Course Outcomes: After the completion of the course the student will be able to

CO 1	Understand the principles, operation, and limitations of DC motor drives and develop suitable speed control schemes for different types of electrical machines. (Cognitive knowledge level: Apply)
CO 2	Analyze speed control techniques and performance characteristics of AC motor drives, under different operating conditions. (Cognitive knowledge level: Analyse)
CO 3	Evaluate the performance of stepper motor and SRM drives by comparing speed control schemes and selecting suitable power converters for different operating requirements. (Cognitive knowledge level: Evaluate)
CO 4	Apply the principles of operation and control of BLDC and PMSM drives, including appropriate power controllers and control methods for different operating conditions. (Cognitive knowledge level: Apply)

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2		2	1	3	2
CO 2	2		2	1	3	2
CO 3	2		2	1	3	2
CO 4	2		2	1	3	2

Evaluation Pattern

	ADVANCED ELECTRIC DRIVES		
Bloom's Category	**Continuous Internal Evaluation Tests**		**End Semester Examination (% Marks)**
	Test 1 (% Marks)	**Test 2 (% Marks)**	
Remember	-	-	-
Understand	20	20	20
Apply	40	40	40
Analyse	40	40	40
Evaluate	-	-	-
Create	-	-	-

Mark distribution

Total Marks	CIE marks	ESE marks	ESE Duration
100	60	40	2 Hours

Continuous Internal Evaluation : 60 marks

Self-study (Seminar*) : 10 marks

Course based task/Micro Project/

Data collection and interpretation/Case study : 20 marks

Test paper 1 (Module 1 and Module 2) : 15 marks

Test paper 2 (Module 3 and Module 4) : 15 marks

*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course.

End Semester Examination (ESE) : 40 marks

The end semester examination will be conducted by the College. Total duration of the examination will be 2 Hrs and will contain 6 questions, with minimum one question from each module of which student should answer any four. Each question can carry 10 marks and can have maximum 2 sub-divisions.

SYLLABUS

MODULE 1 (11 hours)

DC Motor Drives

Electric drives - introduction, DC motor drives - single phase half and fully controlled rectifier fed separately excited DC (SEDC) motor - discontinuous and continuous modes, regenerative braking, three-phase fully controlled drives - continuous conduction, dual converter fed drive, rectifier control of series motor, chopper control of SEDC motor - multiquadrant operation, closed loop speed control.

MODULE 2 (11 hours)

AC Motor Drives

Three phase induction motor drives - torque equation, equivalent circuit, V/F control , slip speed controlled VSI and CSI drive , analysis of induction motor fed from non-sinusoidal voltage supply, static rotor resistance control, slip power recovery schemes for below and above base speed, synch ronous motor drives - true synchronous mode and self-synchronous mode, load commutated drive.

MODULE 3 (12 hours)

Stepper Motor and SRM Drives

Stepper motor and drives - variable reluctance, permanent magnet and hybrid motors - principle of operation, torque production, static position error, pull-in and pull-out characteristics, resonance issues, unipolar and bipolar drive schemes, bifilar drives, open loop position control - starting/stopping rate, velocity profiling.

Switched Reluctance Motors (SRM) and drives - principle of operation, inductance profile, torque equation, motoring and regeneration, low speed and high-speed operation, torque - speed characteristics, energy conversion loop - energy effectiveness, power controllers, control schemes - six switch converter, split dc supply converter, R dump, C dump converters.

MODULE 4 (11 hours)

BLDC and PMSM Drives

Brushless DC motors (BLDC) and drives - permanent magnet materials and characteristics, principle, speed-torque characteristics, torque pulsation, power controllers - full wave and half wave, regeneration, hall sensor-based control, sensor less control, third harmonic voltage detection, starting.

Permanent Magnet Synchronous Motors (PMSM) and drives - principle, SPM and IPM machines, torque equation, phasor diagram, power controllers.

References

1. G. K Dubey, *Power Semiconductor Controlled Drives*, Prentice Hall, 2nd Ed., 2000.
2. G. K Dubey, *Fundamentals of Electrical Drives*, Narosa Publishers, 2nd Ed., 2002.
3. Bimal K Bose, *Modern Power Electronics & AC Drives*, Prentice Hall of India, 1st Ed., 2014.
4. Werner Leonhard, Control *of Electrical Drives*, Springer, 3rd Ed., 2007.
5. Kenjo T, Sugawara A, *Stepping Motors and their Microprocessor Control*, Clarendon Press,Oxford, 2nd Ed., 2010.
6. Paul Acarnley, *Stepping motors - a guide to theory and practice*, 4th Ed., IET UK, 2002
7. Miller T J E, *Switched Reluctance Motor and their Control*, Clarendon Press, Oxford, 2nd Ed., 2008.
8. R Krishnan, *Permanent Magnet Synchronous and brushless dc drives*, CRC Press, 2nd Ed., 2010.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1: DC Motor Drives	**11**
1.1	Introduction to electric drives, drive components, efficiency improvements compared to fixed speed drives	1
1.2	DC motor drives - single phase fully controlled rectifier fed separately excited DC (SEDC) motor - discontinuous and continuous modes, analysis	2
1.3	DC motor drives – single phase half-controlled rectifier fed separately excited DC (SEDC) motor - continuous conduction, power factor improvements, analysis	2
1.4	Regenerative braking of controlled rectifier fed separately excited DC (SEDC) motor, commutation issues	1
1.5	Three-phase fully controlled drives - continuous conduction	2
1.6	Dual converter fed drive - four quadrant operation, dc and ac circulating currents	1
1.7	Rectifier control of series motor, chopper control of SEDC motor - multiquadrant operation, closed loop speed control	2
	Module 2: AC Motor Drives	**11**
2.1	Three phase squirrel cage induction motor drives - introduction, basic equations and equivalent circuit	1
2.2	V/F control - open loop and closed loop	1
2.3	Slip speed controlled VSI and CSI drive	2
2.4	Harmonic equivalent circuit, analysis of induction motor fed from non-sinusoidal voltage supply	2

2.5	Three phase squirrel wound rotor induction motor drives - introduction, static rotor resistance control	2
2.6	Slip power recovery schemes for below and above base speed, synchronous motor drives - introduction, basic equations, true synchronous mode and self-synchronous mode	2
2.7	Load commutated synchronous motor drive	1
	Module 3: Stepper Motor and SRM Drives	**12**
3.1	Stepper motor and drives - variable reluctance, permanent magnet and hybrid motors - introduction	1
3.2	Principle of operation, torque production	1
3.3	Static position error	1
3.4	Pull-in and pull-out characteristics, resonance issues	1
3.5	Bifilar, unipolar and bipolar drive schemes	1
3.6	Open loop position control - starting/stopping rate, velocity profiling	1
3.7	Switched Reluctance Motors (SRM) and drives - principle of operation	1
3.8	Inductance profile, torque equation	1
3.9	Motoring and regeneration- low speed and high-speed operation, torque vs speed characteristics	1
3.10	Energy conversion loop - energy effectiveness	1
3.11	Power controllers, control schemes - six switch converter	1
3.12	Split dc supply converter, R dump, C dump converters	1
	Module 4: BLDC and PMSM Drives	**11**
4.1	Permanent magnet materials and characteristics	1
4.2	Brushless DC Motors (BLDC) and drives – introduction, principle of operation, modelling	2
4.3	Speed-torque characteristics, torque pulsation	1
4.4	Power controllers- full wave and half wave, regeneration	2
4.5	Hall sensor based control	1
4.6	Sensor less control - third harmonic voltage detection, starting	1
4.7	Permanent Magnet Synchronous Motors (PMSM) and drives - principle, SPM and IPM machines	1
4.8	Torque equation, phasor diagram, power controllers	2

M Tech in Power Electronics

Model Question Paper

QP CODE: Pages: 2

Reg No.:_____

Name:_____

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIRST SEMESTER M. TECH DEGREE EXAMINATION, DECEMBER 2026

Course Code: M26EE1E104D

Course Name: ADVANCED ELECTRIC DRIVES

Max. Marks:40 Duration: 2 hours

PART A

Answer any 4 questions. Each question carries 10 marks.

1. a) With necessary circuit diagrams, explain how a non- circulating type dual converter fed separately excited DC drive can outperform a circulating current dual converter. Compare the demerits also. (4 marks)

   b) Draw the circuit schematic of (i) a three-phase half controlled separately excited dc motor drive (ii) three phase full controlled drive and compare the performance in terms of torque ripple and supply power factor. (6 marks)

2. a) Compare V/F control scheme of IM with slip speed control scheme. (4 marks)

   b) A 400V, 60 Hz, 1155 RPM, 6 pole, Y connected, 3 phase wound rotor induction motor has the following parameters referred to the stator: Rs=0.12Ω, Rr‟ =0.1Ω, Xs=0.2Ω, Xr‟ =0.15Ω. The stator to rotor turns ratio is 1.2 and the dc link inductor has a resistance of 0.025Ω. The motor speed is controlled by static Scherbius drive designed for a speed range of 25% below the synchronous speed. Maximum permissible value of firing angle is 168A. Calculate (i) Transformer turns ratio (ii) Torque for a speed of 900 rpm and α=120A (iii) Firing angle for rated motor torque and speed of 800 rpm. (6 marks)

3. a) A three phase, 2 NM, 0.0005Kgm2, VR stepping motor has 16 stator teeth and 20 rotor teeth and is used to drive a frictional load of 0.2 Nm (a) Draw the approximate holding torque curve and mark the no load equilibrium points (b) What is the static position error at load? (c) What is the stepping rate corresponding to a speed of 30 rpm? (6 marks)

b) With necessary sketches, explain the difference between unifilar drive and bifilar steppermotor drivers. (4 marks)

4. a) What do you mean by airgap line, recoil line, and magnet stabilization? Explain why themaximum energy product point is not a preferred operating point. Compare NdFeB, SmCo, Alnico and ceramic magnets for use in permanent magnet machines in terms of the above terms. (4 marks)

   b) A three-phase switched reluctance motor with six stator poles and four rotor poles has a stator pole arc of 28° and a rotor pole arc of 32°. The aligned inductance is 10 mH and the unaligned inductance is 5 mH. Neglect fringing and saturation (a) Draw the cross section of the motor at the aligned and unaligned positions (b) Draw the phase inductance vs. rotor position for all the phases (c) Assuming ideal current waveforms with peak phase current of 2A, plot the instantaneous torque developed vs. rotor position for motoring operation and breaking operation for all the phases. (6 marks)

5. a) With necessary sketches and waveforms, explain the difference between R dump and C dump converters for SRM. (4 marks)

   b) A three phase VR stepping motor with 50 rotor teeth is operated in one phase on scheme. The pull in rate of the motor on no load is 500 steps/sec. A light load having negligible inertia is directly coupled to the motor shaft. Using a microcontroller/microprocessor the motor is to be controlled such that the shaft is rotated 180˚ in the forward direction exactly in 50ms and back to the original position in the next 100ms. Draw the drive circuit, give sequences for full step operation and write an algorithm for the operation. (6 marks)

6. a) Explain the difference between SPM and IPM in terms of machine inductances and extended speed of operation. Also explain the term 'self-control' in connection with PMSM. (4 marks)

   b) Derive the torque-speed characteristics of a BLDC motor and compare with that of a dc shunt motor. If a PM brushless DC motor has a torque constant of 0.12 N m/A (i) Estimate its no-load speed in rpm when connected to a 48 V d.c. supply. (ii) If the armature resistance is 0.15 Ω/phase and the total voltage drop in the controller transistors is 2 V, determine the stall current and the stalltorque. (6 marks)

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M26GE1R105	RESEARCH METHODOLOGY & IPR	Theory	2	0	0	4	2

Preamble

Research methodology and intellectual property rights form an essential foundation for postgraduate students and research scholars engaged in advanced engineering studies. This course introduces the principles of scientific research, problem identification, experimental and analytical methods,and effective technical communication. It also emphasizes ethical research practices, scholarly publication processes,and the protection of intellectual property arising from research and innovation. The course aims to equip M Tech students and research scholars with the skills required to conduct systematic research, communicate findings effectively, and understand the legal and ethical frameworks governing intellectual property and technology development.

Pre-requisite

Nil

Course Outcomes: After the completion of the course the student will be able to

CO 1	Explain the principles, processes, and characteristics of scientific research and apply creative and logical thinking approaches for identifying research directions. (Cognitive Knowledge Level: Understand).
CO 2	Apply literature survey techniques and analytical reasoning to identify research gaps and formulate well-defined research problems. (Cognitive Knowledge Level: Apply).
CO 3	Analyze experimental data and develop appropriate experimental or modelling approaches for solving engineering research problems. (Cognitive Knowledge Level: Analyze)
CO 4	Demonstrate effective technical communication while adhering to research ethics and intellectual property regulations. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2		2		1	1
CO 2	3	1	2	1	2	1
CO 3	3		2	2	3	1
CO 4	1	3	2		1	3

Assessment Pattern

Course Name	Research Methodology & IPR		
Bloom's Category	Continuous Assessment Tests		End Semester Examination (%Marks)
	Test 1 (% Marks)	Test 2 (% Marks)	
Remember	20		
Understand	40	40	40
Apply	40	40	40
Analyse		20	20
Evaluate			
Create			

Mark Distribution

Total Marks	CIE marks	ESE marks	ESE Duration
100	60	40	2 Hours

Continuous Internal Evaluation Pattern

Self-study (Preparing a review article based on peer reviewed original publications in therelevantdiscipline (minimum 10 publications shall be referred)) : 10 marks

Course based task/Seminar/Quiz : 20 marks

Test paper 1 (Module 1 and Module 2) : 15 marks

Test paper 2 (Module 3 and Module 4) : 15 marks

End Semester Examination Pattern

The end semester examination will be conducted by the college. The time duration will be 2 hours and will contain 6 questions, with minimum one question from each module of which student should answer any four. Each question carries 10 marks.

SYLLABUS

MODULE 1 (6 Hours)

Foundations of Research and Creative Thinking

Meaning, objectives and significance of research – types of research, basic, applied and interdisciplinary research – characteristics of good research and stages in the research process – skills, habits and attitudes required for researchers – motivation for research with discussion of Richard Hamming's lecture *"You and Your Research"* – thinking skills in research, levels and styles of thinking, common sense versus scientific thinking, logical reasoning and decomposition of complex problems – creativity in research, definitionsand characteristics, intelligence versus creativity, creative thinking process and requirements for innovation.

MODULE 2: (5 Hours)

Literature Survey and Research Problem Formulation

Importance of literature survey in research – sources of scientific information, journals, conferencepapers, patents and technical reports – techniques for information search using digital databases – reading, documentation and referencing practices – integration of research literature and identification ofresearch gaps – attributes and sources of research problems – problem formulation and research questions – multiple approaches to solving research problems – techniques for problem representation, graphical methods and reasoning – analytical and analogical reasoning – creative problem solving approaches including TRIZ.

MODULE 3 (8 Hours)

Experimental Design, Modelling and Data Analysis

Scientific method and hypothesis formulation – experimental variables, dependent and independent variables, control and reproducibility in experiments – precision, accuracy and measurement errors – random and systematic errors, detection and reduction – statistical treatment and interpretation of experimental data – principles of design of experiments and experimental documentation – modelling in engineering research, types of models and stages in modelling – curve fitting and approximations – mathematical representation and logical reasoning in models – continuum, meso and microscalemodelling approaches – introduction to numerical simulation methods with illustrative case studies.

MODULE 4 (6 Hours)

Technical Communication, Research Ethics and Intellectual Property Rights

Importance of effective communication in research – communication process and barriers – oral communication skills for seminars, conferences and project presentations – preparation and delivery of technical presentations – guidelines for effective presentation slides – principles of scientific writing – structure of technical papers, theses and reports – language, layout, typography, tables and figures – referencing and citation styles – tools for document preparation including LaTeX – scholarly publications including journals and conferences – journal selection and peer review process – research metrics – plagiarism, research integrity and ethical publication practices- Introduction to Intellectual Property Rights

– types of IPR: patents, copyrights, trademarks and industrial designs – patent concepts, objectives and patentability criteria – patent application procedures and documentation – technology transfer and IPR agreements.

References

1. Panneerselvam, R., *Research Methodology*, PHI Learning, New Delhi.
2. Kothari, C. R. and Garg, G., *Research Methodology: Methods and Techniques*, New Age International.
3. Phillips, E. M. and Pugh, D. S., *How to Get a PhD*, Viva Books.
4. Leedy, P. D. and Ormrod, J. E., *Practical Research: Planning and Design*, Pearson.
5. Day, R. A. and Gastel, B., *How to Write and Publish a Scientific Paper*, Cambridge University Press.
6. Thiel, D. V., *Research Methods for Engineers*, Cambridge University Press.
7. Bouchoux, D. E., *Intellectual Property: The Law of Trademarks, Copyrights, Patents and Trade Secrets*.
8. Resnik, D. B., *The Ethics of Science: An Introduction*, Routledge.
9. Medawar, P., *Advice to a Young Scientist*.
10. Wilson, E. O., *Letters to a Young Scientist*.
11. Hamming, R., *You and Your Research*, Bell Labs Lecture.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
Module 1		**6**
1.1	Meaning, objectives and significance of research – types of research: basic, applied and interdisciplinary	1
1.2	Characteristics of good research – stages in the research process	1
1.3	Skills, habits and attitudes required for researchers – motivation for research – discussion of Richard Hamming's lecture "You and Your Research"	1
1.4	Thinking skills in research – levels and styles of thinking – common sense versus scientific thinking	1
1.5	Logical reasoning and decomposition of complex problems	1
1.6	Creativity in research – intelligence versus creativity – creative thinking process and requirements for innovation	1
Module 2		**5**
2.1	Importance of literature survey – sources of scientific information: journals, conference papers, patents and technical reports	1
2.2	Techniques for information search using digital databases	1
2.3	Reading, documentation and referencing practices	1
2.4	Integration of research literature and identification of research gaps	1
2.5	Research problem formulation – attributes and sources of research problems – research questions – introduction to problem representation and TRIZ	1

Module 3		**8**
3.1	Scientific method and hypothesis formulation	1
3.2	Experimental variables – dependent and independent variables – control and reproducibility in experiments	1
3.3	Precision, accuracy and measurement errors – random and systematic errors	1
3.4	Detection and reduction of experimental errors – statistical treatment and interpretation of experimental data	1
3.5	Principles of design of experiments – experimental documentation	1
3.6	Modelling in engineering research – types of models and stages in modelling	1
3.7	Curve fitting, approximations and mathematical representation of models	1
3.8	Continuum, meso and micro scale modelling approaches – introduction to numerical simulation methods with examples	1
Module 4		**6**
4.1	Importance of communication in research – communication process and barriers	1
4.2	Oral communication skills – preparation and delivery of technical presentations – presentation slide design	1
4.3	Scientific writing – structure of technical papers, theses and reports – referencing and citation styles	1
4.4	Scholarly publications – journal selection – peer review process – research metrics	1
4.5	Research ethics – plagiarism, research integrity and ethical publication practices	1
4.6	Intellectual Property Rights – types of IPR – patentability criteria – patent application procedures – technology transfer	1

MODEL QUESTION PAPER

QP CODE: Pages: 1

Reg. No.: ……..

Name : ……..

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS) KOTHAMANGALAM

FIRST SEMESTER M TECH DEGREE EXAMINATION, DECEMBER 2026

Course Code: M26GE1R105
Course Name: RESEARCH METHODOLOGY & IPR

Max. Marks: 40 Duration: 2 hours

*Answer any **four** questions. Each question carries 10 marks.*

1	a.	Explain the stages in the research process and the characteristics of good research.	(5 marks)
	b.	Discuss the role of creative and logical thinking in research with suitable examples from engineering research.	(5 marks)
2	a.	Describe the methods used for conducting an effective literature survey and the different sources of research information.	(5 marks)
	b.	A researcher intends to study energy efficiency improvement in electric vehicles. Explain how the researcher can identify research gaps and formulate a research problem based on literature survey.	(5 marks)
3	a.	Explain the scientific method and hypothesis formulation in experimental research.	(5 marks)
	b.	An experiment measures the temperature of a furnace multiple times giving the following readings (°C): 650, 652, 648, 651, 649. Calculate the mean temperature and comment on the precision of the measurements.	(5 marks)
4	a.	Explain the concept and stages of modelling in engineering research.	(6 marks)
	b.	Discuss the importance of approximations and curve fitting in engineering models with examples.	(4 marks)
5	a.	Explain the structure of a scientific research paper and the important rules of scientific writing.	(5 marks)
	b.	Discuss the principles for preparing effective technical presentation slides for conferences or seminars.	(5 marks)
6	a.	Explain the peer review process and discuss the criteria used for selecting a suitable journal for publication.	(5 marks)
	b.	Explain the concept of patents, the criteria for patentability, and the steps involved in the patent filing process.	(5 marks)

SEMESTER II

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M26EE1D201	COMPUTATIONAL OPTIMIZATION FOR ENGINEERING APPLICATIONS	Discipline Core	3	0	3	6	5

Preamble: This course provides a foundation to formulate and solve engineering optimization problems using appropriate computational techniques. It covers optimization techniques for linear and nonlinear systems with and without constraints. This course will equip the students with the mathematical framework necessary for optimization of engineering systems for various applications.

Prerequisite: B. Tech level Mathematics.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Apply linear optimization techniques and algorithms to solve engineering problems. (Cognitive knowledge level : Apply)
CO 2	Formulate, implement and analyze unconstrained one dimensional optimization models. (Cognitive knowledge level : Analyze)
CO 3	Use unconstrained and constrained n dimensional optimization techniques for engineering applications and be familiar with recent developments in optimization techniques. (Cognitive knowledge level : Analyze)
CO 4	To implement appropriate optimization algorithms for solving Engineering Problems and apply optimization techniques to solve practical power electronic problems. (Cognitive knowledge level : Apply)

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	1	3	3	3	2
CO 2	2	1	3	3	3	2
CO 3	2	1	3	3	3	2
CO 4	2	1	3	3	3	3

Assessment Pattern

	COMPUTATIONAL OPTIMIZATION FOR ENGINEERING APPLICATIONS		
Bloom's Category	**Continuous Internal Evaluation Tests**		**End Semester Examination (% Marks)**
	Test 1 (% Marks)	**Test 2 (% Marks)**	
Remember	-	-	-
Understand	-	-	-
Apply	40	40	40
Analyse	60	60	60
Evaluate	-	-	-
Create	-	-	

Mark distribution

Total Marks	**CIE marks**	**ESE marks**	**ESE Duration**
100	60	40	2 Hours

Continuous Internal Evaluation Pattern:

Theory evaluation: 30 marks

Self-study (Course based task/Seminar/Quiz) :10 marks

Test paper 1 :10 marks

Test paper 2 :10 marks

Project based learning: 30 marks

Mini-project 1 :10 marks

Mini-project 2 :10 marks

Mini-project 3 :10 marks

End Semester Examination Pattern: The end semester examination will be conducted by the college. The time duration will be 2 hrs and will contain 6 questions from first three modules, with minimum one question from each module of which student shall answer any four. Each question carry 10 marks and can have maximum 2 sub divisions.

SYLLABUS

MODULE 1 (9 hours)

Linear Programming Problems(LPP)

Formulation of optimization problems - Classification of Optimization Problems - Linear Programming Problems- Graphical method – Iso - profit (or Iso-cost) line method -Extremepoint evaluation method- Types of optimal solution - Standard Form - Definitions and Theorems - Simplex method – Big M Method –Duality in Linear Programming.

MODULE 2 (9 hours)

Nonlinear unconstrained one dimensional optimization techniques

Unimodal functions – Unimodal maximum and minimum, Search methods - Fibonacci search – Golden section search, Interpolation methods - Quadratic interpolation - Cubic interpolation. Unconstrained one dimensional optimization using direct root methods - Newton method - Quasi Newton method - Secant method.

MODULE 3 (12 hours)

Nonlinear unconstrained n dimensional optimization techniques

Gradient methods- Steepest descent method - Conjugate gradient method – Newton'smethod – Davidon Fletcher Powell method.

Constrained optimization techniques

Necessary and sufficient conditions, Equality and inequality constraints, Kuhn Tucker conditions – Solution of optimization problems using Kuhn – Tucker conditions.

Recent developments in optimization techniques

Genetic algorithm based and Neural network based optimization techniques.

MODULE 4 (30 hours)

Project –based learning : Optimization of Engineering Systems

Students work individually or in small groups to apply optimization techniques to practical engineering or power electronic problems using simulation tools such as MATLAB/ Simulink/ Python.

Formulation of optimization problems for engineering systems, Modelling and simulation of systems, Implementation of optimization algorithms, Performance evaluation and comparison of results.

Example Project Topics:

1. Optimization of parameters of DC–DC converters for improved efficiency.
2. Minimization of output voltage ripple in switching converters.
3. Optimization of PWMswitching strategies in inverters for THD reduction.
4. Optimal tuning of PI/PID controllers in power electronic converters.

5. Optimal design of LC filters for harmonic reduction.
6. Efficiency optimization of power electronic systems.

References

1. Rao, S. S., Engineering Optimization: Theory and Practice, 5th Edition, John Wiley & Sons, New York, 2020.
2. Chong, E. K. P., Zak, S. H., and Lu, W.-S., An Introduction to Optimization: With Applications to Machine Learning, 5th Edition, John Wiley & Sons, Hoboken, NJ, 2023.
3. Fathi, M. and Bevrani, H., Optimization in Electrical Engineering, 1st Edition, Springer, Cham, Switzerland, 2019.
4. Bazaraa, M. S., Sherali, H. D., and Shetty, C. M., Nonlinear Programming: Theory and Algorithms, 3rd Edition, John Wiley & Sons, Hoboken, NJ, 2006.
5. Goldberg, D. E., Genetic Algorithms in Search, Optimization, and Machine Learning, 1st Edition, Addison-Wesley Publishing Company, Reading, MA, 1989.
6. Deb, K., Optimization for Engineering Design: Algorithms and Examples, 2nd Edition, PHI Learning Pvt. Ltd., New Delhi, 2012.
7. Raju, N. V. S., Optimization Methods for Engineers, 1st Edition, PHI Learning Pvt. Ltd., New Delhi, 2014..
8. Panneerselvam, R., Operations Research, 3rd Edition, PHI Learning Pvt. Ltd., New Delhi, 2024.
9. Verma, A. P., Operations Research, Revised Edition, S. K. Kataria & Sons, New Delhi, 2011.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1	**9**
1.1	Formulation of optimization problems	1
1.2	Classification of Optimization Problems	1
1.3	Linear Programming Problems- Graphical method – Iso - profit (or Iso-cost) line method - Extreme point evaluation method.	2
1.4	Standard Form - Definitions and Theorems	1
1.5	Simplex method	2
1.6	Big M Method	1
1.7	Duality in Linear Programming.	1
	Module 2	**9**
2.1	Unconstrained one dimensional optimization techniques – Introduction.	1
2.2	Search methods - Fibonacci search	1
2.3	Golden section search	1
2.4	Interpolation methods- Quadratic interpolation	1
2.5	Cubic interpolation.	1
2.6	Unconstrained one dimensional optimization using direct root methods - introduction	1
2.7	Newton's method	1

2.8	Quasi Newton method	1
2.9	Secant method.	1
	Module 3	**12**
3.1	Unconstrained n dimensional optimization techniques	1
3.2	Gradient methods- Steepest descent method	1
3.3	Conjugate gradient method	1
3.4	Newton's method	1
3.5	Davidon Fletcher Powell method.	1
3.6	Constrained optimization techniques - Introduction	1
3.7	Necessary and sufficient conditions - Equality and inequality constraints.	1
3.8	Kuhn Tucker conditions	1
3.9	Solution of optimization problems using Kuhn – Tucker conditions	2
3.10	Recent developments in optimization techniques : Genetic algorithm	1
3.11	Neural network based optimization techniques.	1
	Module 4	**30**
4.1	Mini-project 1	10
4.2	Mini-project 2	10
4.3	Mini-project 3	10

Model Question Paper

QP CODE: Pages: 1

Reg No.:_____

Name:_____

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

SECOND SEMESTER M.TECH DEGREE EXAMINATION, MAY 2027

Course Code: M26EE1D201

Course Name: COMPUTATIONAL OPTIMIZATION FOR ENGINEERING APPLICATIONS

Max. Marks:40 Duration: 2 hours

Answer any 4 questions. Each question carries 10 marks.

1. Evaluate the optimal solution using simplex method

Minimize $Z = x_1-3x_2+2x_3$

Subject to $3x_1-x_2+2x_3 \leq 7$

$-2x_1+4x_2 \leq 12$

$-4x_1+3x_2+8x_3 \leq 10$

$x_1,x_2,x_3 \geq 0$

2. Evaluate the optimal solution using big-M method

Maximize $Z = 5x_1+3x_2$

Subject to $2x_1+x_2 \leq 1$

$x1+4x2 \geq 6$

$x1,x2 \geq 0$

3. Obtain the minimum of the function $f(x) = x^5 - 10x^3+2x+10$ in (1,6) using quadratic interpolation method.

4. Find the minimum of the function $f(x) = 0.65 - 0.75/(1+x^2) – 0.65x \tan^{-1}(1/x)$ using Secant method with starting point 0 and initial step size 0.1.

5. Minimize the function, $f(x)= x_1-x_2+2x_1^2+2x_1x_2+x_2^2$ starting from point $x_1= [0\ 0\ ]$ using steepest descend method.

6. Derive the optimal solution from the Kuhn-Tucker conditions for the problem.

Minimize $Z=2x_1+3x_2-x_1^2-2x_2^2$

subject to the condition $x_1 + 3x_2 \leq 6,\ 5x_1+ 2x_2 \leq 10,,\ x_1,x_2 \geq 0$.

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M26EE1D202	MODELLING AND CONTROL OF ELECTRIC DRIVES	Programme Core	4	0	0	4	4

Preamble: The syllabus focuses on the dynamic modeling and advanced drive-control schemes applicable to induction machines, permanent magnet synchronous motors (PMSM), and brushless DC (BLDC) motors. Students will gain knowledge to model an electrical machine using the modelling equations and analyze the control techniques of the drives. Students will also be able to model and analyze electrical machines using transfer function and state-space representation techniques to solve engineering problems.

Prerequisite:

Electrical Machines, Power Electronics, Control System.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Understand the modelling of induction machine using reference frame theory and anlayze the vector control schemes. (Cognitive Knowledge Level: Analyze)
CO 2	Analyze the characteristic features of PMSM and its control strategies. (Cognitive Knowledge Level: Analyze)
CO 3	Design suitable control strategies for BLDC motor and examine the sensorless control methods. (Cognitive Knowledge Level: Analyze)
CO 4	Simulate the modelling of electrical machine theory in different reference frames and apply the vector control technique in electrical machines. (Cognitive Knowledge Level: Analyze)

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	2	3	3	3	2
CO 2	3	2	3	3	3	2
CO 3	3	2	3	3	3	2
CO 4	3	2	3	3	3	2
CO 5	3	2	3	3	3	2

Assessment Pattern

	MODELLING AND CONTROL OF ELECTRIC DRIVES		
Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination (%Marks)**
	Test 1 (%Marks)	**Test 2 (%Marks)**	
Remember			
Understand	30	30	30
Apply	20	20	20
Analyze	30	30	30
Evaluate	20	20	20
Create			

Mark distribution

Total Marks	**CIA marks**	**ESE marks**	**ESE Duration**
100	60	40	3 Hours

Continuous Internal Evaluation Pattern:

Evaluation shall only be based on application, analysis or design based questions (for both internal and end semester examinations).

Continuous Internal Evaluation (CIE) **: 60 marks**

Theory Evaluation **: 30 marks**

Self-study

(Course based task/Seminar/ Quiz/ Micro project) :10 marks

Test paper 1 :10 marks

Test paper 2 :10 marks

Lab Evaluation **: 30 marks**

Lab work : 10 marks

Final evaluation Test : 20 marks

(Note: 50% of Module 1, 2 and 3 may be considered for each test)

End Semester Examination (ESE) **: 40 marks**

The end semester examination should be conducted by the college. The time duration will be 2 Hrs and will contain 6 questions from the first three modules, with a minimum one question from each module of which student should answer any four. Each question can carry 10 marks and can have a maximum of 2 subdivisions.

SYLLABUS

MODULE 1 (16 hours)

Modelling and control of Induction Machine

Generalized machine theory- Basic two-pole machine- Transformer and rotational voltages in the armature- Kron's primitive machine- Voltage, power and torque equations- Resistance, inductance and torque matrices.
Modelling of Induction Machine: Space vector representation, power equivalence - 3-phase to 2-phase transformation, dynamic modelling of induction machines in arbitrary reference frame– electromagnetic torque, Stator reference frame, rotor reference frame and synchronously rotating reference frame models, dynamic and steady state equivalent circuits.

Field Oriented Control: Principle of vector or field-oriented control – Comparison with separately excited dc motor- direct rotor flux-oriented vector control – Selection of Flux level- Estimation of rotor flux and torque- Indirect rotor flux-oriented vector control scheme- Flux weakening- Parameter sensitivity - implementation with current regulated VSI and PWMVSI- Speed controller design, Direct torque control (DTC) of induction motor.

MODULE 2 (7 hours)

Modelling and control of PMSM

Permanent magnet synchronous machine (PMSM) drives – types of permanent magnets and characteristics–radial and parallel magnetization- Halbach arrays- SPM and IPM machines- Modelling of PMSM- Vector control strategies – constant torque-angle control- unity power factor control- maximum torque per ampere- constant mutual flux linkage control- flux weakening.

MODULE 3 (7 hours)

Modelling and control of BLDC

PM brushless (BLDC) DC motor – modeling of BLDC motor – operating principle- Speed-Torque characteristics- Torque Pulsation- Six switch converter- Split supply Converter- Drive scheme without field weakening- Current and Speed Control- Regenerative braking- Sensor less control- back emf detection method.

MODULE 4 (30 hours)

Simulation Experiments:

1. Simulation of Vector control of 3 phase induction motor
2. Simulation of Direct Torque control of Induction motor drive
3. Simulation of vector control of PMSM

4. State space Modeling and Simulation of BLDC motor drive
5. Simulation of a separately excited DC motor drive with closed loop control for four quadrant operation
6. Modeling of induction machine in synchronous reference frame, rotor reference frame and stator reference frame.
7. Modelling of PMSM using Matlab Simulink
8. Modelling of BLDC machine using Matlab Simulink
9. Hardware implementation of v/f control of induction machine.
10. Hardware implementation of vector control of induction machine.

References

1. R. Krishnan, *Electric Motor Drives,* PHI, 2007
2. B. K. Bose, *Modern Power Electronics and AC Drives,* PHI, 2006
3. R. Krishnan, *Permanent Magnet Synchronous and Brushless dc drives,* CRC Press, 2010 Reference Books.
4. P. C. Krause, Wasynczuk and Sudhoff, *Analysis of Electric Machinery and Drive Systems*, Wiley, 2004
5. A.M. Trzynadlowski, *Field orientation Principle in the control of Induction Motors*, Kluwer, 1994
6. Ned Mohan, *Advanced Electric Drives- Analysis, Control and Modelling*, John Wiley, 2014

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1	**16**
1.1	Generalized machine theory- Basic two-pole machine	1
1.2	Transformer and rotational voltages in the armature	1
1.3	Kron's primitive machine- Voltage, power and torque equations- Resistance, inductance and torque matrices	1
1.4	Modelling of Induction Machine: Air gap MMF due to sinusoidal winding distribution- Space vector representation	1
1.5	Power equivalence- 3-phase to 2-phase transformation	1
1.6	Dynamic modelling of induction machines in arbitrary reference frame – electromagnetic torque	1
1.7	Stator reference frame, rotor reference frame and synchronously rotating reference frame models	1
1.8	Dynamic and steady state equivalent circuits	1
1.9	Direct rotor flux-oriented vector control	2
1.10	Selection of Flux level- Estimation of rotor flux and torque	1
1.11	Indirect rotor flux-oriented vector control scheme	1
1.12	Parameter sensitivity	1
1.13	Implementation with current regulated VSI and PWM VSI	1
1.14	Flux weakening	1
1.15	Speed controller design	1
1.16	Direct torque control (DTC) of induction motor	1

	Module 2	**7**
2.1	Types of permanent magnets and characteristics	1
2.2	Radial and parallel magnetization- Halbach arrays	1
2.3	SPM and IPM machines	1
2.4	Modelling of PMSM	1
2.5	Vector control strategies – constant torque-angle control- unity power factor control- maximum torque per ampere- constant mutual flux linkage control	2
2.6	Flux weakening	1
	Module 3	**7**
3.1	PM brushless (BLDC) DC motor – modeling of BLDC motor Current and Speed Control	1
3.2	Operating principle- Speed-Torque characteristics- Torque Pulsation-	1
3.3	Six switch converter- Split supply Converter	1
3.4	Drive scheme without field weakening	1
3.5	Regenerative braking	1
3.6	Sensor less control- back emf detection method	2
	Module 4	**30**
4.1	Simulation of Vector control of 3 phase induction motor	3
4.2	Simulation of Direct Torque control of Induction motor drive	3
4.3	Simulation of vector control of PMSM	3
4.4	State space Modeling and Simulation of BLDC motor drive	3
4.5	Simulation of a separately excited DC motor drive with closed loop control for four quadrant operation	3
4.6	Modeling of induction machine in synchronous reference frame, rotor reference frame and stator reference frame.	3
4.7	Modelling of PMSM using Matlab Simulink	3
4.8	Modelling of BLDC machine using Matlab Simulink	3
4.9	Hardware implementation of v/f control of induction machine.	3
4.10	Hardware implementation of vector control of induction machine.	3

Model Question Paper

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MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

SECOND SEMESTER M.TECH DEGREE EXAMINATION, MAY 2027

Course Code: M26EE1D202

Course Name: MODELLING AND CONTROL OF ELECTRIC DRIVES

Max. Marks:40 Duration: 2 hours

Answer any four questions. Each question carries 10 marks.

1. Derive the dynamic equations of an induction machine in a stationary reference frame.
2. Discuss the impact of current control (hysteresis control) and PWM control on the performance of vector-controlled induction motor drive.
3. Explain the direct vector control scheme of induction motor drive and how torque and flux references are estimated.
4. Compare between FOC and DTC control schemes of induction motor drive on the basis of performance.
5. Illustrate in detail the various vector control strategies used in permanent magnet synchronous motor.
6. Select a suitable drive scheme for a BLDC motor and explain the performance during rated and extended speed operations.

PROGRAM ELECTIVE II

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M26EE1E203A	FACTS AND CUSTOM POWER DEVICES	Elective	4	0	0	5	4

Preamble: This course introduces the fundamentals of modern power transmission challenges and the evolution of Flexible AC Transmission Systems (FACTS) as effective solutions. It covers key concepts, devices, and control strategies used to enhance power quality, stability, and transmission efficiency in electrical power systems. The course also emphasizes practical analysis through numerical problems and explores advanced controllers and custom power devices used in real -world applications.

Prerequisite: Basic knowledge of power systems, power electronics and control systems at UG level.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Use FACT controllers for various power quality issues (Cognitive Knowledge Level : Understand)
CO 2	Design and analyze shunt and series compensators for solving reactive power problems in power systems (Cognitive Knowledge Level : Analyze)
CO 3	Learn to Optimize the performance of power system using combination of series and shunt Compensators (Cognitive Knowledge Level : Apply)
CO 4	Develop and promote research interests in controllers for reducing consumer end problems in power systems. (Cognitive Knowledge Level : Apply)

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	1	3	3	3	2
CO 2	3	1	3	3	3	2
CO 3	3	1	3	3	3	2
CO 4	3	1	3	3	3	2

Evaluation Pattern

	FACTS AND CUSTOM POWER DEVICES		
Bloom's Category	**Continuous Internal Evaluation Tests**		**End Semester Examination (%Marks)**
	Test 1 (%Marks)	**Test 2 (%Marks)**	
Remember	-	-	-
Understand	30	30	30
Apply	50	50	50
Analyse	20	20	20
Evaluate	-	-	-
Create	-	-	-

Mark distribution

Total Marks	CIE marks	ESE marks	ESE Duration
100	60	40	2 Hours

Continuous Internal Evaluation Pattern:

Self-study (Seminar*) :10 marks

Course based task//Micro Project/Data collection and interpretation/Case tudy :20 marks

Test paper 1 (Module 1 and Module 2) :15 marks

Test paper 2 (Module 3 and Module 4) :15 marks

*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course.

End Semester Examination Pattern: The end semester examination will be conducted by the College. Total duration of the examination will be 2 Hrs and will contain 6 questions, with minimum one question from each module of which student should answer any four. Each question can carry 10 marks and can have maximum 2 sub-divisions.

SYLLABUS

Module I (9 hours)

Emergence of FACTS

Power transmission problems and emergence of facts solutions: Fundamentals of ac power transmission, power quality – basic concept. Voltage regulation and reactive power flow control- needs, emergence of FACTS- types of FACTS controllers-advantages and disadvantages - shunt compensation - series compensation -phase angle control –basic relationships. Numerical problems.

Module II (14 hours)

Shunt Compensators

Objectives of shunt compensation-shunt SVCTCR – TSC – effect of initial charge - combined TCR and TSC configurations – characteristics - analysis -elimination of harmonics – control schemes – STATCOM-configuration and control, comparison between SVC and STATCOM– applications, Numerical problems

Static series compensation

Objectives- GCSC – TSSC – TCSC characteristics – basic Control Schemes - sub synchronous characteristics-basic NGH SSR Damper - Static Synchronous Series Compensator (SSSC): Principle of operation – analysis and characteristics - control scheme, Numerical problems

Module III (10 hours)

Unified power flow controller (UPFC)

Principles of operation and characteristics, independent active and reactive power flow control, comparison of UPFC to the controlled series compensators, control structure and dynamic performance. Interline Power Flow Controller (IPFC) – basic operating principles and characteristics and control schemes. Numerical problems

Module IV (12 hours)

Custom Power Devices

Types – configuration – SSCL – SSCB – SSTS – compensation – filters - static voltage & phase angle regulator - TCVL- TCVR- TCBR -Distribution STATCOM– dynamic voltage restorer – Unified Power Quality Conditioner – Application of DSTATCOM, DVR and UPQC- case studies.

Reference Books

1. Song, Y.H and Allan. T. Johns, *Flexible AC Transmission Systems (FACTS*), Institution of Electrical

Engineers Press, 1st Ed., 1999.
2. Hingorani, L Gyugyi, *Concepts and Technology of Flexible AC Transmission System*, IEEE Press New York, 1st Ed., 2000
3. K R Padiyar, *FACTS Controllers in Power Transmission and Distribution*, New Age International Publishers, 1st Ed., 2007.
4. S Denesh Kumar, *Flexible AC Transmission System*, Anuradha Publishers, 1st Ed., 2013.
5. Ned Mohan, *Advanced Electronics drives- Analysis, Controland Modeling*, John Willey, 1st Ed., 2014
6. Nagrath I J and Kothari S D P, *Modern Power System Analysis*, TMH, 4th Ed., 2011

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1: Emergence of FACTS	**9**
1.1	Power transmission problems and emergence of facts solutions: Fundamentals of ac power transmission	2
1.2	Power quality – basic concept, voltage regulation and reactive power flow control	2
1.3	Needs, emergence of FACTS- Types of FACTS controllers-Advantages and disadvantages	2
1.4	Shunt compensation - series compensation ,phase angle control –basic relationships	2
1.5	Numerical problems.	1
	Module 2 : Shunt Compensators	**14**
2.1	Shunt compensators ,objectives of shunt compensation-shunt SVCTCR–TSC – Effect of initial charge	2
2.2	Combined TCR and TSC configurations – characteristics , analysis - elimination of harmonics –control schemes	2
2.3	STATCOM- configuration and control, comparison between SVC and STATCOM – applications, Numerical problems	2
2.4	Static series compensation , objectives- GCSC – TSSC – TCSC characteristics basic control schemes	2
2.5	Sub synchronous characteristics- basic NGH SSR damper	2
2.6	Static Synchronous Series Compensator (SSSC): Principle of operation – analysis and characteristics - control scheme	2
2.7	Numerical problems	2
	Module 3 : Unified power flow controller (UPFC)	**10**
3.1	Unified power flow controller (UPFC): Principles of operation and characteristics	2
3.2	Independent active and reactive power flow control	2
3.3	Comparison of UPFC to the controlled series compensators, control structure and dynamic performance	2

3.4	Interline Power Flow Controller (IPFC) – Basic operating Principles characteristics and control schemes	2
3.5	Numerical problems	2
	Module 4 : Custom Power Devices	**12**
4.1	Types – configuration – SSCL – SSCB – SSTS	2
4.2	Compensation – Filters	1
4.3	Static voltage & phase angle regulator - TCVL- TCVR- TCBR	2
4.4	Distribution STATCOM – Dynamic Voltage Restorer	2
4.5	Unified Power Quality Conditioner	1
4.6	Application of DSTATCOM, DVR and UPQC- case studies	2

Model Question Paper

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MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM
SECOND SEMESTER M.TECH DEGREE EXAMINATION, MAY 2027

Course Code: M26EE1E203A

Course Name: FACTS AND CUSTOM POWER DEVICES

Max. Marks:40 Duration: 2 hours

PART A

Answer any four questions. Each question carries 10 marks.

1. Describe the purpose of FACTS devices in a power system and classify the different types of FACTS controllers.

2. Explain how the initial charge of a capacitor influences the operation of a Thyristor Switched Capacitor (TSC).

3. The particulars of a transmission line with TCR are V=220V, f = 50Hz, X=1.2Ω, Power = 56kW. The maximum current of TCR is 120A. Find i). Phase angle ii). Line current iii)Reactive Power iv).Current through TCR v). Inductive reactance of TCR and delay angle of TCR if the current is 50% of the maximum current.

4. Derive the expression for real and reactive power (P&Q) in UPFC and plot the variation with load angle.

5. Examine the necessity of custom power devices in a power system and assess their advantages in enhancing power quality and overall system performance.

6. Analyze the working principle of a static voltage regulator and evaluate its effectiveness in achieving voltage stability objectives within a power system.

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M26EE1E203B	SOLAR AND WIND POWER CONVERSION SYSTEMS	Elective	4	0	0	5	4

Preamble: Solar and wind power conversion systems together take a lion's share in the whole of renewable energy conversion systems today. This course focuses on the selection, design and utilization of solarandwind power conversion systems. This course equips students to design solar PV and wind power conversionsystems.

Prerequisite: Basic course in Power Electronics.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Develop a solid foundation in solar and wind energy conversion systems. (Cognitive Knowledge Level: Understand)
CO 2	Analyze and design standalone and grid-connected solar PV systems, including MPPT algorithms.(Cognitive Knowledge Level: Apply)
CO 3	Analyze and design grid-connected wind energy conversion systems. (Cognitive Knowledge Level : Apply)
CO 4	Evaluate the selection and performance of different aerogenerators. (Cognitive Knowledge Level : Analyze)

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	1	2	1	3	1
CO 2	2	1	2	1	3	1
CO 3	2	1	2	1	3	1
CO 4	2	1	2	1	3	1

Evaluation Pattern

	SOLAR AND WIND POWER CONVERSION SYSTEMS		
Bloom's Category	**Continuous Internal Evaluation Tests**		**End Semester Examination (%Marks)**
	Test 1 (%Marks)	**Test 2 (%Marks)**	
Remember	-	-	-
Understand	25	25	25
Apply	50	50	50
Analyse	25	25	25
Evaluate	-	-	-
Create	-	-	-

Mark distribution

Total Marks	**CIE marks**	**ESE marks**	**ESE Duration**
100	60	40	2 Hours

Continuous Internal Evaluation Pattern:

Self-study (Seminar*) :10 marks

Course based task//Micro Project/Data collection and interpretation/Case tudy :20 marks

Test paper 1 (Module 1 and Module 2) :15 marks

Test paper 2 (Module 3 and Module 4) :15 marks

*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course.

End Semester Examination Pattern: The end semester examination will be conducted by the College . Total duration of the examination will be 2 Hrs and will contain 6 questions, with minimum one question from each module of which student should answer any four. Each question can carry 10 marks and can have maximum 2 sub-divisions.

SYLLABUS

Module I (11 hours)

Solar Cells

Sun and earth- Basic characteristics of solar radiation- solar cell characteristics- construction- generation of photo electricity- equivalent circuit- losses in solar cells, energy conversion efficiency- effect of variation of solar insolation and temperature on efficiency- types of solar PV- monocrystalline, polycrystallineandthinfilm- performance and comparison.

Module II (12 hours)

Solar PV modules

Series and parallel connection of cells- design and selection of PV module- partial shading of solar cells and modules- measurement of voltage and current- protection- batteries for PV systems- lead acid andlithium-ion batteries- characteristics- charging and discharging rate- protection.

MPPT Algorithms

Open circuit voltage and short circuit current- Perturb and Observe- Incremental conductance- realisation of MPPT using DC-DC converters- buck, boost and buck-boost- comparison.

Module III (11 hours)

State space analysis

Solar PV system design: system level design of standalone and grid connected systems- inverter topologies- LCL filter- net metering- isolation- grounding and protection- relevant IEEE standards- single axis and dualaxis tracking.

Module IV (11 hours)

Wind energy

Energy in the wind- aerodynamics- rotor types- forces developed by blades- aerodynamic models- braking systems- tower- control and monitoring system- design considerations- power curve- power speed characteristics.

Wind turbine generator systems:

Choice of electrical generators- fixed speed induction generator- semi variable speed induction generator- variable speed induction generators with full and partial rated power converter topologies - performance analysis.

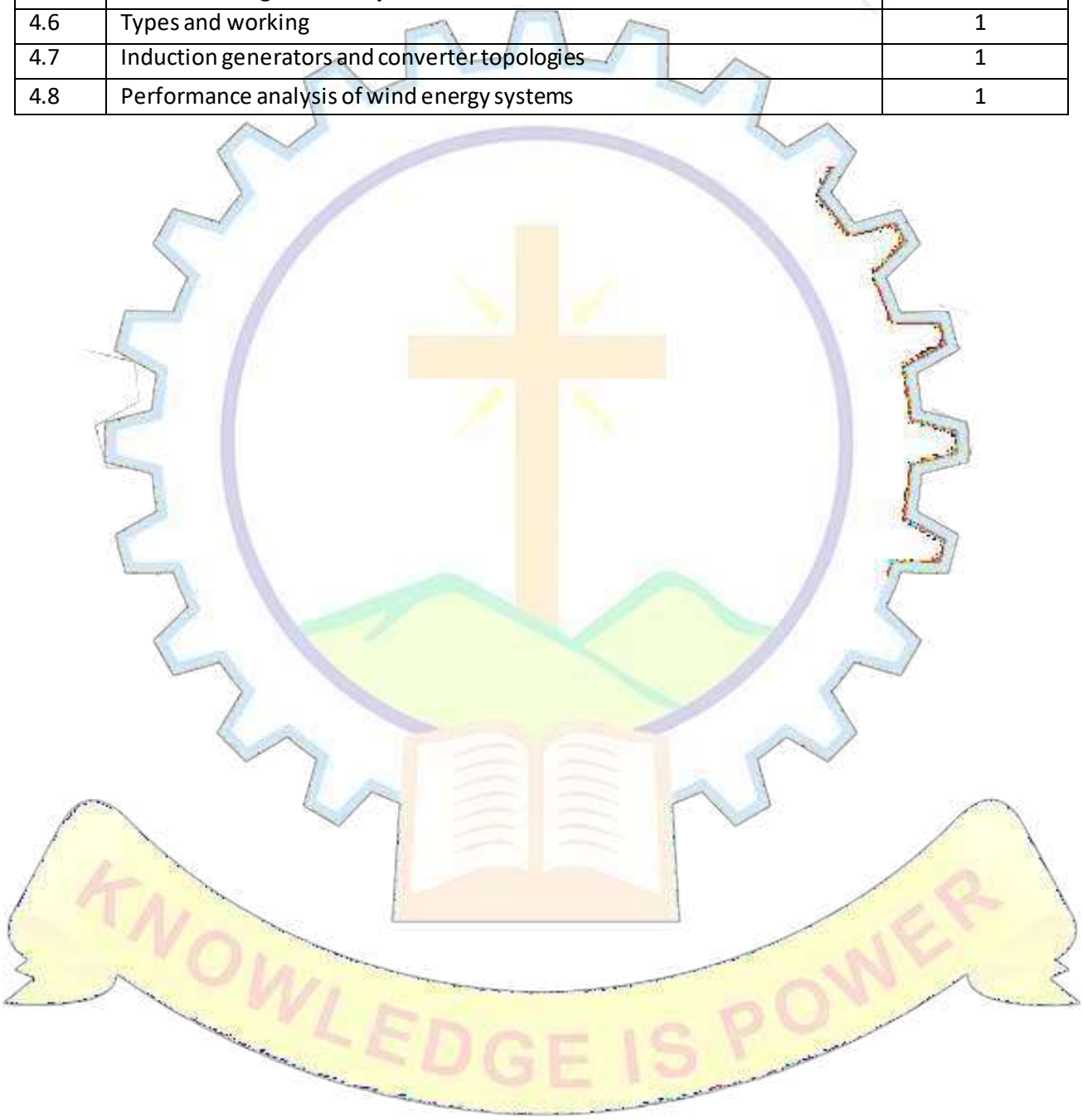
Reference Books

1. Chetan Singh Solanki, *Solar Photovoltaics-Fundamentals, Technologies and Applications*,PHI Learning Pvt. Ltd., New Delhi, 3rd ed., 2015.
2. Anne Labouret and Michel Villoz, *Solar Photovoltaic Energy*, IET, 1st ed ,2010
3. S.N. Bhadra, D. Kastha and S. Banerje, *Wind Electrical Systems*, Oxford Uni Press, 1st ed ,2005.
4. Siegfried Heier, Rachel Waddington, *Grid Integration of Wind Energy Conversion Systems*, Wiley, 1st ed ,2006,
5. John F.Walker & Jenkins. N , *Wind Energy Technology*, John Wiley and sons, Chichester, UK, 1st ed ,1997.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1: Solar Cells	**11**
1.1	Sun and earth, basics of solar radiation	2
1.2	Solar cell characteristics, construction, generation of photoelectricity	2
1.3	Equivalent circuit of solar cell	1
1.4	Losses in solar cells and energy conversion efficiency	2
1.5	Effect of solar insolation and temperature on efficiency	1
1.6	Types of solar PV: monocrystalline, polycrystalline, thin film	2
1.7	Performance and comparison of PV technologies	1
	Module 2: Solar PV modules	**12**
2.1	PV modules: series and parallel connections, design and selection	2
2.2	Partial shading in solar cells and modules	1
2.3	Measurement of voltage and current, protection	1
2.4	Batteries: lead-acid and lithium-ion, characteristics	2
2.5	Charging and discharging rate, protection	1
	MPPT Algorithms	
2.6	Open circuit voltage and short circuit current methods	1
2.7	Perturb & Observe and Incremental Conductance methods	2
2.8	DC-DC converters: buck, boost, buck-boost and comparison	2
	Module 3: State space analysis	**11**
3.1	System-level design of standalone and grid-connected PV systems	3
3.2	Inverter topologies and LCL filter	2
3.3	Net metering	1
3.4	Isolation, grounding and protection	2
3.5	Relevant IEEE standards	1
3.6	Solar tracking: single-axis and dual-axis	2
	Module 4: Wind energy	**11**

4.1	Wind energy fundamentals and energy in wind	1
4.2	Aerodynamics, rotor types, forces on blades	2
4.3	Aerodynamic models	1
4.4	Wind turbine components: braking, tower, control and monitoring	2
4.5	Design considerations, power curve, power-speed characteristics	2
	Wind turbine generator systems	
4.6	Types and working	1
4.7	Induction generators and converter topologies	1
4.8	Performance analysis of wind energy systems	1



Model Question Paper

QP CODE: Pages: 2

Reg No.:_____

Name:_____

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM
SECOND SEMESTER M.TECH DEGREE EXAMINATION, MAY 2027

Course Code: M26EE1E203B

Course Name: SOLAR AND WIND POWER CONVERSION SYSTEMS

Max. Marks:40 Duration: 2hours

PART A

Answer any four questions. Each question carries 10 marks.

1. Explain the principle of operation of PN junction solar cell and discuss any realistic equivalent circuit. Also discuss the methods used to improve the solar cell efficiency.
2. Calculate the efficiency and peak power of Si solar cell operating at 27 deg.C, with short circuit current of 2.2 A and operating under standard illumination of 1000W/m2. The area of the solar cell is 100 cm2. If the operating temperature of the solar cell increases to 35 deg. C, Calculate the efficiency. (Assume FF = 0.75, I0 = 10-12)
3. Explain in detail the series-parallel mismatch in PV module configuration and possible remedies.
4. Design a Standalone PV (SPV) system to be used at Cochin (9.9312° N, 76.2673° E) for which the load requirements are given in the table. The system should allow the use of non-sunshine hours for ONE day. The operating hours and power rating of these loads are also given.

Load	Rating (watts)	Hours/day	Quantity
LED Bulb	9	5	3
TV	2000	1	1
BLDC Fan	40	5	2
Computer	250	2	1

5. A wind turbine is operating with a tip speed ratio of 5. If the angle of attack is 6° and the wind speed is 10 m/s, determine the blade pitch angle at the tip of the blade.
6. With necessary circuit schematics, explain variable speed induction generators with partial rated power converter topologies.

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M24EE1E203C	DESIGN OF POWER ELECTRONIC SYSTEMS	Elective	4	0	0	5	4

Preamble: Proper design and selection of power electronic components is crucial for the successful and reliable operation of power electronic products. This course covers magnetic component design, passive elements, and the integration of power converters with attention to efficiency, reliability, and performance. This course will equip the students with the knowledge and skills required to design EMC-compliant, high-frequency power electronic systems for a wide range of applications.

Prerequisite: Basic course in Power Electronics at UG level.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Develop gate drive schemes for different types of switching devices after understanding pertinent limitations of simple drive schemes (Cognitive knowledge level: Apply)
CO 2	Analyse different gate drive schemes, design protection circuits and snubbers, and therma requirements to design effective cooling systems (Cognitive knowledge level: Evaluate)
CO 3	Design of magnetics, filter capacitors and bus bars (Cognitive knowledge level: Apply)
CO 4	Design of power converters for electromagnetic compatibility (Cognitive knowledge level: Apply)

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	1		3			
CO 2	1		2		3	
CO 3	1		2		3	
CO 4	2	1				3

Evaluation Pattern

Bloom's Category	DESIGN OF POWER ELECTRONIC SYSTEMS		
	Continuous Internal Evaluation Tests		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	-	-	-
Understand	20	20	20
Apply	40	40	40
Analyse	40	40	40
Evaluate	-	-	-
Create	-	-	

Mark distribution

Total Marks	CIE marks	ESE marks	ESE Duration
100	60	40	2 Hours

Continuous Internal Evaluation Pattern : 60 marks

Seminar* : 10 marks

Course based task/Micro Project/

Data collection and interpretation/Case study : 20 marks

Test paper 1 (Module 1 and Module 2) : 15 marks

Test paper 2 (Module 3 and Module 4) : 15 marks

*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course

End Semester Examination (ESE) : 40 marks

The end semester examination will be conducted bythe college. Total duration of the examination willbe 2 hrs and will contain 6 questions, with minimum one question from each module of which student should answer any four. Each question can carry10 marks and can have maximum 2 sub-divisions.

SYLLABUS

MODULE 1 (11 Hours)

Advanced gate drive systems

High frequency diodes- reverse recovery issues- fast and soft recovery schottky diodes- loss computation in diodes- base/gate drive requirements – design of base/gate drive for Power transistors, MOSFET and IGBTs- dc coupled drive circuits- isolated drive circuits, bootstrapping - cascode transistor driver- gate drive considerations for SiC MOSFET- gate drive power requirements- Protection in drive circuits- dead time requirements- overcurrent and desaturation protection-noise suppression- ferrite beads- pcb layout considerations for gate drives

MODULE 2 (12 Hours)

Protection, snubbers & thermal management

Snubber circuits- need for snubber- diode snubbers - safe operating area (SOA) of switching devices- device loss computation with and without snubber design of turn-off and turn-on snubbers- energy recovery snubbers- snubber for bridge circuit configurations. Cooling and design of heat sinks- heat transfer by conduction, radiation and convection- thermal analogy- control of device temperature- selection of heat sink- thermal resistance due to radiation and convection-natural cooling-forced air cooling- pulsed power and transient thermal impedance .

MODULE 3 (12 Hours)

Magnetic design & passive components

Design of inductors -selection of core material and size- core loss and winding losses- reductionofskin effect- leakage inductance- design of high frequency transformers for sine wave and square wave inverters, push-pull, half bridge, full bridge, fly back and forward converters- selection of filter capacitors- bus bars- case study: design of buck converter, quadratic buck, fly black and single phase PWM rectifier

MODULE 4 (10 Hours)

EMI/EMC & system integration

EMI and EMC- introduction- characteristics of switching processes of power devices- Electromagnetic compatibility (EMC)- conductive and radiative EMI- standards- reduction of EMI- common mode filter-LISN- shielding of cables and transformers- PCB layout considerations - case study: buck converter, forward and fly black converters

References

1. Ned Mohan, Tore M. Undeland and William P.Riobbins, *Power Electronics— Converters, Applications and Design*,John Wiley and Sons ,3rd ed., 2014
2. L. Umanand, *Power Electronics-Essentials and Applications*, Wiley, 1st ed., 2014
3. Daniel W. Hart, *Power Electronics*, Tata McGraw Hill, 1st ed., 2011.
4. H.W. Whittington et al., *Switched Mode Power Supplies- Design and Construction ,* University Press, 1st ed., 1997
5. Francois Costa et al., *Electromagnetic compatibility in Power Electronics*, Wiley Iste, 1st ed., 2014
6. Joseph Vithayathil, *Power Electronics-Principle and Applications'*, Tata McGraw Hill Education Pvt Ltd, 1st ed., 2010.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1: Advanced gate drive systems	**11**
1.1	High frequency diodes- reverse recovery issues- fast and soft recovery- schottky diodes- loss computation in diodes	2
1.2	Base drive requirements - design of base drive for power transistors- dc coupled drive circuits- isolated drive circuits, cascode driver	2
1.3	Gate drive requirements- design of base gate drive for MOSFETs and IGBTs- dc coupled drive circuits- isolated drive circuits, bootstrapping	2
1.4	Gate drive considerations for SiC MOSFET	1
1.5	Gate drive power requirements	1
1.6	Protection in drive circuits- dead time requirements - overcurrent and desaturation protection	2
1.7	Noise suppression- ferrite beads- pcb layout considerations for gate drives	1
	Module 2: Protection, snubbers & thermal management	**12**
2.1	Snubber circuits- need for snubber- diode snubbers	1
2.2	Safe operating area (SOA) of switching devices- device loss computation with and without snubbers	2
2.3	Design of turn-off and turn-on snubbers	1
2.4	Energy recovery snubbers	1
2.5	Snubber for bridge circuit configurations	1
2.6	Cooling and design of heat sinks- heat transfer by conduction, radiation and convection	2
2.7	Thermal analogy- control of device temperature, selection of heat sink	2
2.8	Thermal resistance due to radiation and convection- natural cooling	1
2.9	Forced air cooling of heat sinks, pulsed power and transient thermal	1

	impedance	
	Module 3: Magnetic design & power components	**12**
3.1	Design of inductors -selection of core material and core size	1
3.2	Core loss and winding losses	1
3.3	Reduction of skin effect and leakage inductance	1
3.4	Design of high frequency transformers for sine wave and square wave inverters	2
3.5	Design of high frequency transformer for push-pull, half bridge, full bridge	2
3.6	Design of high frequency transformers for fly back and forward converters	2
3.7	Selection of filter capacitors, design of bus bars	1
3.8	Case study: design of buck converter, quadratic buck, fly black converter and single phase PWM rectifier	2
	Module 4: EMI, EMC & PCB design	**10**
4.1	EMI and EMC- introduction	1
4.2	Characteristics of switching processes of power devices	1
4.3	Electromagnetic compatibility (EMC)- conductive and radiative EMI-standards	1
4.4	Reduction of EMI- common mode filter- LISN	2
4.5	Shielding of cables and transformers	2
4.6	PCB layout considerations	1
4.7	Case study: buck converter, forward and fly black converters	2

Model Question Paper

QP CODE: Pages: 2

Reg No.:_____

Name:_____

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIRST SEMESTER M.TECH DEGREE EXAMINATION, MAY 2027

Course Code: M24EE1E203C

Course Name: DESIGN OF POWER ELECTRONIC SYSTEMS

Max. Marks:40 Duration: 2 hours

PART A

Answer any four questions.

1. a. List the important drive requirements of a good BJT drive. (4 marks)
   b. A MOSFET needs 250nC of total gate charge to turn ON. Determine the gate current needed if the MOSFET needs to be turned ON in about 350ns. Draw a suitable gate drive scheme. If the MOSFET is used in an application where the switching frequency is 25kHz, what is the minimum duty cycle percentage possible if the device turn-OFF time is 250ns. (6 marks)

2. a. An RCD snubber is used in a MOSFET based laptop car battery adapter (12 V to 19 V, 2.5 A current output). Calculate the turn-off loss with and without the snubber. The MOSFET is switched at 100kHz and the MOSFET has a turn-off delay time of 90ns and current fall time of 80ns. (4 marks)
   b. Explain the need for snubber network for fast recovery diodes and obtain design equations for the snubbers and draw the instantaneous voltage, current and power waveforms across a typical IGBT during turn-off, without and with an RCD snubber. (6 marks)

3. a. What do you mean by thermal resistance? Explain how its value can be reduced in a heat sink? Also explain the electrical equivalent model of a typical heat sink arrangement. (4 marks)
   b. A power pulse of 500W with a 10µs duration and a duty cycle of 0.2 occurs in a MOSFET that has transient thermal resistance characteristics as shown in figure below. Determine the maximum junction temperature, if the case temperature is 80°C. (6 marks)
4. a. Calculate the skin depth at 2kHz, and at 200kHz for enamelled copper conductors and hence suggest the conductor(s) size to carry a current of 5A RMS at these frequencies. Justify the selection. (4 marks)

b. Select suitable air gap length and number of turns for the transformer in a forward converter. Use EE42/21/20 ferrite core. It is given that battery Voltage=12V, Output voltage=200V, Output power=20W, Switching frequency=25kHz. Make suitable assumptions. (6 marks)

5. a. An inductor is constructed with a U-shaped ferrite core. The core has an area of cross section 200mm2 and mean magnetic path length of 12 cm. The relative permeability of the core is 3000. Calculate the inductance when 55 turns are used for the coil. What is the value of inductance when an air-gap of 4mm is introduced in the flux path? (6 marks)

b. Explain the PCB layout considerations in a flyback converter for EMI reduction. (4 marks)

6. a. Draw the circuit diagram of a forward converter operating at 50kHz, power being drawn from 230V, 50Hz mains. Identify the possible conducted noise emission sources and explain the means to reduce EMI. (4 marks)

b. In a flyback converter, the dc input voltage is 320V and output voltage is 20V. The transformer has a turns ratio of 10:1 and a leakage inductance of 400µH as measured on the high voltage side. The transistor which can be considered as an ideal switch, is driven by a 50KHz square wave. The fast recovery diode of the converter has a reverse recovery time of 100ns (i) Draw the circuit diagram and an equivalent circuit suitable for diode snubber design calculations (ii) Determine suitable snubber capacitor and resistance for the diode. (6 marks)

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M24EE1E203D	MULTILEVEL INVERTERS AND MODULATION TECHNIQUES	Elective	4	0	0	5	4

Preamble : This course aims to impart knowledge on multilevel inverter topologies and their modulation techniques for high-performance power conversion. It covers advanced PWM methods, harmonic control strategies, and operational challenges such as voltage balancing, losses, and common mode effects. This course equips students e to select appropriate multilevel inverter configurations and analyze modular multilevel converters for various industrial, power system, and automotive applications.

Prerequisite : Basic course in Power Electronics at UG level.

Course Outcomes : After the completion of the course the student will be able to

CO 1	Identify suitable multilevel inverter topology (Cognitive knowledge level: Understand)
CO 2	Analyze the performance of the multilevel inverter topology (Cognitive knowledge level: Apply)
CO 3	Analyze the operational issues and identify suitable mitigation methods (Cognitive knowledge level: Analyse)
CO 4	Identify suitable modular multilevel inverter topology and control schemes (Cognitive knowledge level: Analyse)

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	1	2	1	2	1
CO 2	2	1	2	1	3	1
CO 3	2	1	2	2	3	2
CO 4	2	1	2	1	3	1

Evaluation Pattern

	MULTILEVEL INVERTERS AND MODULATION TECHNIQUES		
Bloom's Category	**Continuous Internal Evaluation Tests**		**End Semester Examination (%Marks)**
	Test 1 (%Marks)	**Test 2 (%Marks)**	
Understand	20	20	20
Apply	40	40	40
Analyse	40	40	40
Evaluate			

Mark distribution

Total Marks	CIE marks	ESE marks	ESE Duration
100	60	40	2 Hours

Continuous Internal Evaluation Pattern:

Seminar* : 10 marks

Course based task/Micro Project/

/Data collection and interpretation/Case study : 20 marks

Test paper 1 (Module 1 and Module 2) : 15 marks

Test paper 2 (Module 3 and Module 4) : 15 marks

*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course

End Semester Examination Pattern: The end semester examination will be conducted by the College. Total duration of the examination will be 2 Hrs and will contain 6 questions, with minimum one question from each module of which student should answer any four. Each question can carry 10 marks and can have maximum 2 sub-divisions.

SYLLABUS

MODULE 1 (12 hours)

Multilevel Inverter Topologies

Multilevel (ML) Inverters- advantages- comparison with two-level inverters - diode clamped ml inverter- three level and five level- flying capacitor multilevel inverter- three level and four levels- cascaded multilevel inverters-symmetrical and asymmetrical topologies of CHB- derived multilevel topologies- ANPC- t-type multilevel inverters- packed U- cell topology- hybrid multilevel topologies- open end winding scheme.

MODULE 2 (11 hours)

PWM Techniques for Multilevel Inverters

Modulation of two level and multilevel inverters – sinusoidal pwm- third harmonic and triple-n harmonic injection PWM- concept of space vectors (SV) - space vector modulation- discontinuous pwm- basic schemes- advantages - SVM for ML inverters based on two level SVM algorithm.

MODULE 3 (11 hours)

Advanced Modulation and Harmonic Control Methods

Selection of voltage vectors for PWM- identification of nearest vectors- duty cycle computation- vector selection and switching- classical approach- hexagon decomposition method- method based on hexagonal coordinate system- identification of nearest vectors and dwell timings- carrier based space vector modulation- level shifted and phase shifted PWM-fundamental frequency control schemes- introduction to selective harmonic elimination for ML inverters.

MODULE 4 (11 hours)

Operational Issues and Modular Multilevel Converters

Operational Issues- neutral point voltage balancing in diode clamped multilevel inverter- losses- capacitor voltage balancing in flying capacitor inverters - charge balance using phase shift PWM- dynamic voltage balancing- common mode voltage and reduction of bearing currents- modular multilevel converters- introduction- advantages- principle of operation-sub module configurations, classical control methods- pulse width modulation schemes- phase shifted carrier modulation scheme- voltage control- capacitor voltage balancing strategies, circulating current issues and control of circulating current- applications of multilevel and modular multilevel inverters- applications in power systems- traction and automotive applications- case studies.

References

1. D. Grahame Holmes, Thomas A Lipo, *Pulse Width Modulation for Power converters- Principles and Practice*, John Wiley and sons, 1st ed., 2003
2. Ersan Kabalc, *Multilevel Inverters Introduction and emergent topologies"*, Academic Press, 1st ed., 2021
3. Daniel W. Hart, *Power Electronics*, McGrawHill, 1st ed., 2011
4. Bin Wu, *High Power Converters and AC Drives*, Wiley -IEEE, 1st ed., 2006
5. Jae Hyeong Seo, Chang Ho Choi and Dong Seok Hyun, A New Simplified Space Vector PWM Method for Three-Level Inverters, IEEE Transactions on Power Electronics, Vol. 16, No. 4, July 2001.
6. S. Gonzales, S. Verne, M. Valla, *Multilevel Converters for Industrial Applications*, CRC, 1st ed., 2014
7. A.M. Trzynadlowski, *Introduction to Modern Power Electronics*, Wiley, 2nd ed., 2010
8. Nikola Celanovic, and Dushan Boroyevich, *A Fast Space-Vector Modulation Algorithm for Multilevel Three-Phase Converters*, IEEE Transactions on Industry Applications, Vol. 37, No. 2, March/April 2001

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1: Multilevel inverter topologies	**12**
1.1	Multilevel (ML) inverters- advantages- comparison with two-level inverters	2
1.2	Diode clamped ML inverter- three level and five level	2
1.3	Flying Capacitor multilevel inverter- three level and four levels	2
1.4	Cascaded multilevel inverters-symmetrical and asymmetrical Topologies of CHB	2
1.5	Derived multilevel topologies-ANPC	1
1.6	T-type multi-level inverters-packed U-cell topology	1
1.7	Hybrid multilevel topologies	1
1.8	Open end winding scheme for ML inverters	1
	Module 2: PWM techniques for multilevel inverters	**11**
2.1	Modulation of two level and multilevel inverters –sinusoidal PWM	2
2.2	Third harmonic and triple-n harmonic injection PWM	2
2.3	Concept of space vectors (SV) - space vector modulation (SVM) for multilevel inverters	3
2.4	Discontinuous PWM- basic schemes- advantages	2
2.5	SVM for ML inverters based on two level SVMalgorithm	2
	Module 3: Advanced modulation and harmonic control methods	**11**
3.1	Selection of voltage vectors for PWM- identification of nearest vectors- duty cycle computation- vector selection and switching-classical approach	3
3.2	Hexagon decomposition method- identification of nearest vectors and dwell timings	2
3.3	Hexagonal coordinate system-identification of nearest vectors and dwell timings	2
3.4	Carrier based space vector modulation-level shifted and phase shifted PWM	2
3.5	Fundamental frequency control schemes	1
3.6	Selective harmonic elimination for ML inverters- introduction	1
	Module 4 : Operational issues and modular multilevel converters	**11**
4.1	Operational issues- neutral point voltage balancing in diode clamped multilevel inverter	2
4.2	Losses in ML inverters	1
4.3	Capacitor voltage balancing in flying capacitor inverters - charge balance using phase shift PWM- dynamic voltage balancing	2
4.4	Common mode voltage and reduction of bearing currents	1
4.5	Modular multilevel converters- introduction- advantages- principle of operation-submodule configurations	2

4.6	Classical control methods- pulse width modulation schemes- phase shifted carrier modulation scheme- voltage control-capacitor voltage balancing strategies	1
4.7	Circulating current issues and control of circulating current	1
4.8	Applications of multilevel and modular multilevel inverters- applications in power systems- traction and automotive applications- case studies	1

Model Question Paper

QP CODE: Pages: 2

Reg No.:_____

Name:_____

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIRST SEMESTER M.TECH DEGREE EXAMINATION, MAY 2027

Course Code: M24EE1E203D

Course Name: MULTILEVEL INVERTERS AND MODULATION TECHNIQUES

Max. Marks:40 Duration: 2 hours

PART A

Answer any four questions. Each question carries 10 marks.

1. a. Compare and contrast three level NPC and T-type multilevel inverters. (4 marks)
   b. Illustrate the circulating current issues in modular multilevel inverters and the control of circulating current. (6 marks)

2. a. Explain carrier based SPWM technique used in multi-level inverters. (4 marks)
   b. Explain different types of voltage control techniques used in modular multilevel converters. (6 marks)

3. a. With the help of a neat figure, explain phase shifted carrier modulation scheme. Mention the advantages compared to level shifted PWM. (4 marks)
   b. Explain discontinuous PWM in two-level and multi-level inverters. (6 marks)

4. a. Discuss the effect of common mode currents on the bearings and the use of ML inverters to reduce the common mode currents. (4 marks)
   b. Illustrate the operation of four-level flying capacitor inverter and any capacitor balancing scheme. (6 marks)

5. a. Explain hexagonal decomposition PWM for three level inverters. (4 marks)
   b. Draw the circuit of a five-level cascaded multilevel inverter and explain its working. Also explain any fundamental frequency voltage control scheme. (6 marks)

6. a. With a neat figure, explain the space vector modulation of three level inverter based on a two-level mapping of space vector diagram. (4 marks)

   b. Explain the neutral point voltage balancing issues in NPC inverters and discuss any one of the one possible remedy. (6 marks)

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M26EE1S204	ELECTRIC CHARGING SYSTEMS FOR ELECTRICAL VECHICLES	Industry Integrated Course	4	0	0	5	4

Preamble: The course is aimed to provide an overview of the technological concepts and regulatory frameworks related to the charging systems of Electrical Vehicle. It covers various energy storage mechanisms, types of chargers and charging standards used in Electric vehide. Upon successful completion students will be well equipped with the charging systems of electric vehicle.

Prerequisite: Fundamentals of Power Electronics

Course Outcomes: After the completion of the course the student will be able to

CO 1	Analyse the working of different types of controlled rectifiers and choppers (Cognitive knowledge level: Apply)
CO 2	Describe the energy storage mechanisms used for EV's (Cognitive knowledge level: Understand)
CO 3	Explain the various types of chargers used for EV's (Cognitive knowledge level: Understand)
CO 4	Illustrate the various types of charging standards used for EV's (Cognitive knowledge level: Understand)

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2			1		1
CO 2	2			1		1
CO 3	2			1		1
CO 4	2			1		2

Evaluation Pattern

	ELECTRIC CHARGING SYSTEMS FOR ELECTRICAL VECHICLES		
Bloom's Category	**Continuous Internal Evaluation Tests**		**End Semester Examination (% Marks)**
	Test 1 (% Marks)	**Test 2 (% Marks)**	
Understand	50	70	50
Apply	50	30	50
Analyse	-		
Evaluate	-	-	-
Create	-	-	-

Mark distribution

Total Marks	**CIE marks**	**ESE marks**	**ESE Duration**
100	60	40	2 Hours

Continuous Internal Evaluation

Self-study (Seminar*) :10 marks

Course based task//Micro Project/Data collection and interpretation/Case study :20 marks

Test paper 1 (Module 1 and Module 2) :15 marks

Test paper 2 (Module 3 and Module 4) :15 marks

*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course.

End Semester Examination

The examination will be conducted by the college with the question paper provided by the industry. The examination will be for 2 hrs. and will contain 6 questions, with minimum one question fromeach module of which student should answer any four. Each question can carry 10 marks. The valuation of the answer scripts shall be done by the expert in the industry handling the course.

SYLLABUS

MODULE 1 (13 hours)

Review of controlled rectifiers and DC-DC converters

Three phase converter - half-wave controlled rectifier with R load, 3-phase fully controlled converter with RLE load, continuous conduction mode, output voltage equation, waveforms for various triggering angles.
Single-quadrant, two-quadrant and four-quadrant chopper, pulse width modulation in dc - dc converters. Switched mode regulators – buck, boost and buck-boost converters, waveforms, design of filter inductance and capacitance. Numerical problems.

MODULE 2 (12 hours)

Energy storage systems

Introduction to energy storage requirements in electric vehicles, battery parameters-charge capacity, energy storage, State-of-Charge (SOC), EV batteries – types, battery modelling - Peukert's law of battery behaviour, battery based energy storage systems - power conversion, protection and safety, and thermal management systems, battery charging, fuel cell, ultra-high speed flywheels, and super capacitors based energy storage, hybridization of different energy storage

MODULE 3 (10 hours)

EV chargers

On-board chargers - types, Electric Vehicle Supply Equipment (EVSE) - grid to EVSE to on-board chargers to battery pack, power flow block schematic diagrams, types of charging stations - AC level 1 & 2, DC - level 3, wireless EV charging systems – working principle, block diagram, plug-in hybrid EV, V2G concept.

MODULE 4 (10 hours)

Charging standards

SAE J1772, VDE-AR-E 2623-2-2, JEVS G105-1993, types of connectors - CHAdeMO, CCS Type1 and 2, GB/T - pin diagrams and differences, IEC 61851- electric vehicle conductive charging modes, IEC 61980- electric vehicle wireless power transfer systems, IEC 62196 -AC couplers configuration, combo AC-DC couplers and IS- 17017 standards for EV charging.

References

1. Iqbal Hussein, *Electric and Hybrid Vehicles: Design Fundamentals*, CRC Press,4th Ed.,2010.
2. James Larminie, John Lowry, *Electric Vehicle Technology Explained*, Wiley, 2nd Ed., 2003.
3. Mehrdad Ehsani, YimiGao, Sebastian E. Gay, Ali Emadi, *Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design*, CRC Press, 1stEd., 2004.
4. John G. Hayes, *Electric powertrain*, Wiley, 2nd Ed., 2001.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1: Controlled Rectifiers	**13**
1.1	Three phase converter - half-wave controlled rectifier with R load	1
1.2	3-phase fully controlled converter with RLE load, continuous conduction mode	1
1.3	Output voltage equation	1
1.4	Waveforms for various triggering angles	2
1.5	Single quadrant chopper	1
1.6	Two quadrant chopper	1
1.7	Four quadrant chopper	1
1.7	Pulse width modulation in dc-dc converters	1
1.8	Switched mode regulators – buck, boost and buck-boost converters	1
1.9	Waveforms, voltage gain	1
1.10	Design of filter inductance and capacitance, numerical problems	2
	Module 2: Energy storage systems	**12**
2.1	Introduction to energy storage requirements in electric vehicles	1
2.2	Battery parameters-charge capacity, energy storage, State-of-Charge	2
2.3	EV batteries – types	1
2.4	Battery modelling - Peukert's Law of battery behaviour	1
2.5	Battery based energy storage systems - power conversion, protection and safety, and thermal management systems	2
2.6	Battery charging	1
2.7	Fuel cell based energy storage	1
2.8	Ultra-high speed flywheel based energy storage	1
2.9	Super capacitors based energy storage	1
2.10	Hybridization of different energy storage	1
	Module 3: EV chargers	**10**
3.1	On-board chargers - types	1
3.2	Electric Vehicle Supply Equipment (EVSE) - grid to EVSE to on-board chargers to battery pack.	2
3.3	Power flow block schematic diagrams	1

3.4	Types of charging stations - AC Level 1& 2	2
3.5	Types of charging stations DC - Level 3	1
3.6	Wireless EV charging systems –working principle, block diagram	1
3.7	Plug-in Hybrid EV	1
3.8	V2G concept	1
	Module 4: Charging standards	**10**
4.1	Charging standards SAE J1772	1
4.2	Charging standards VDE-AR-E 2623-2-2	1
4.3	Charging standards JEVS G105-1993	1
4.4	Types of connectors - CHAdeMO	1
4.5	CCS Type1and 2	1
4.6	GB/T - pin diagrams and differences	1
4.7	IEC 61851 - electric vehicle conductive charging modes	1
4.8	IEC 61980- electric vehicle wireless power transfer systems	1
4.9	IEC 62196 -AC couplers configuration, combo AC–DC couplers	1
4.10	IS- 17017 standards for EV charging	1

Model Question Paper

QP CODE: Pages: 1

Reg No.:_____

Name:_____

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

SECOND SEMESTER M.TECH DEGREE EXAMINATION, MAY 2027

Course Code: M26EE1S204

Course Name: ELECTRIC CHARGING SYSTEMS FOR ELECTRICAL VECHICLES

Max. Marks:40 Duration: 2 hours

Answer any five questions. Each question carries 12 marks.

1. (a) What is inverted mode of operation of the converter? Explain. (4 marks)
   (b) Draw the circuit of 3 phase converter with RLE load and explain the working for α=600 with necessary waveforms. Derive the expression for average output voltage. (6 marks)
2. (a) What is a two-quadrant chopper? Explain. (4 marks)
   (b) A boost converter has an input voltage of Vd=10V and an average output voltage of 20V and average load current of I0=0.5A.The switching frequency is 25kHz and and L=200µH and C=220µF.Determine (a) duty ratio (b) ripple current of the inductor (c) peak current of inductor and (d) ripple voltage of capacitor. (6 marks)
3. (a) Explain about the battery management systems used in EV. (4 marks)
   (b) Draw the circuit of 3 phase fully controlled rectifier with RL load and explain the working for α=60 degree with necessary waveforms. Derive the expression for output voltage. (6 marks)
4. (a) Draw and explain the configuration of a level-1 charger. (4 marks)
   (b) Explain about Fuel cell-based energy storage systems. (6 marks)
5. (a)Illustrate the power flow from grid to EVSE to on-board chargers to battery with the help of a schematic diagram. (4 marks)
   (b) Explain the operation of level-3 battery charger with a neat circuit diagram. (6 marks)
6. (a) Compare the operation of different types of batteries. (4 marks)
   (b) Describe the various charging standards used for electric vehicles. (6 marks)

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M26EE1P205	MINI PROJECT	PROJECT	0	0	4	6	2

Preamble: Mini project can help to strengthen the understanding of student's fundamentals through application of theoretical concepts and to boost their skills and widen the horizon of their thinking. The aim of an engineering student is to resolve a problem by applying theoretical knowledge. Doing more projects increases problem solving skills.

The introduction of Mini projects ensures preparedness of students to undertake dissertation. Students should identify a topic of interest in consultation with PG programme coordinator that should lead to their dissertation/research project. Demonstrate the novelty of the project through the results and outputs. The progress of the mini project is evaluated based on three reviews, two interim reviews and a final review. A report is required at the end of the semester.

Course Outcome

After completing mini project student should be able to

CO1: Identify and define an **Engineering problem**: Students will be able to select a relevant and feasible problem based on real-world needs, demonstrating originality and clarity in problem definition.

CO2: Conduct **Literature review** and develop a **methodology**: Students will develop the ability to critically review and synthesize existing literature to identify research gaps and establish the context for their study.

CO3: Implement the proposed **methodology** and **analyze results**: Students will be able to execute the methodology, develop a prototype/model/simulation, and analyze the results to validate the objectives.

CO4: **Communicate** the project outcomes effectively: Students will be able to prepare a structured report and present the work clearly, demonstrating technical knowledge, understanding, and involvement.

Course Outcome (CO)	Mapped Program Outcome (PO)	Justification
CO1: Identify and define an Engineering problem	PO1: Ability to independently carry out research/investigation and development work	Identifying a research topic requires independent exploration, critical thinking, and decision-making, forming the foundation for research activities.
	PO3: Demonstrate mastery over the specialization area	Topic selection reflects an understanding of advanced concepts beyond undergraduate level.
CO2: Conduct literature review and develop a methodology	PO1: Ability to independently carry out research/investigation and development work	Literature analysis develops the ability to critically evaluate existing work and identify research gaps.
	PO3: Demonstrate mastery over the specialization area	Analyzing literature demonstrates depth of knowledge in the chosen field.

CO3: Implement the proposed methodology and analyze results	PO1: Ability to independently carry out research/investigation and development work	Defining a problem and planning methodology are key steps in executing independent and systematic research.
	PO4: Apply stream knowledge to design or develop solutions for real-world problems	A well-formulated problem and methodology enable the application of domain knowledge to address practical engineering challenges.
	PO5: Identify, select, and apply appropriate techniques, resources, and tools	Developing methodology involves selecting suitable tools, techniques, and resources required for effective problem-solving.
CO4: Communicate the project outcomes effectively	PO2: Ability to communicate effectively, write and present technical reports	Preparing a structured report enhances technical writing, presentation, and communication skills for conveying research ideas clearly.
	PO6: Engage in life-long learning with consideration of sustainability, societal aspects	A proposal often encourages awareness of broader impacts, fostering continuous learning

Continuous Internal Evaluation

The evaluation committee comprises

1. Project coordinator
2. A senior faculty
3. Project supervisor

Course Outcome (CO)	Marks Allocated	Justification
CO1: Identify and define an Engineering problem	25	Topics election is foundational stage requiring creativity and basic exploration of relevant problems
CO2: Conduct literature review and develop a methodology	25	Literature review is essential for understanding existing work and identifying research gaps through critical analysis.
CO3: Implement the proposed methodology and analyze results	25	Defining the problem is a pivotal step, formulating objectives and methodology demands detailed planning and technical understanding
CO4: Communicate the project outcomes effectively	25	Proposal preparation integrates all prior work into a concise document, focusing on communication
Total	**100**	

Detailed Breakdown and Rationale:

1. **CO1: Identify and define an Engineering problem (25 marks)**
   - This involves identifying a feasible and innovative topic. It's an essential starting point but less complex than subsequent analytical tasks.
   - Assessment: Relevance, originality, and feasibility of the topic.
2. **CO2: Conduct literature review and develop a methodology (25 marks)**
   - A thorough literature review needs significant effort to survey existing work, analyze gaps, and establish context.
   - Assessment: Depth, breadth, and critical evaluation of sources.
3. **CO3: Implement the proposed methodology and analyze results (25 marks)**
   - Involves defining a clear and specific problem, along with formulating objectives and methodology, requiring planning and technical understanding.
   - Assessment: Clarity, specificity, and significance of the problem statement.
4. **CO4: Communicate the project outcomes effectively (25 marks)**
   - The proposal synthesizes all prior work into a structured document. While important for communication, it's less intensive than analysis or planning, hence a slightly lower weight.
   - Assessment: Structure, clarity, and completeness of the proposal

Evaluation Committee - Programme Coordinator, One Senior faculty and Guide.

Sl. No	Type of evaluations	Marks	Evaluation criteria
1	Interim evaluation I	30	Problem identification, literature base, clarity of objectives
2	Interim evaluation II	30	Methodology, progress achieved, depth of knowledge
3	Final evaluation by a Committee	25	Completion level and demonstration of functionality/ specifications, clarity of presentation, oral examination, work knowledge and involvement
4	Report	10	The committee will be evaluating for the technical content, adequacy of references, templates followed and permitted plagiarism level (not more than 25%)
5	Supervisor/Guide	5	Initiative, regularity, involvement
Total Marks		**100**	

Rubrics for Interim Evaluation I (30 Marks)

Parameter	Excellent	Good	Average	Poor
Problem Identification (CO1) (10 marks)	Clearly defined, relevant, innovative, aligned with real-world issues	Relevant but limited innovation	Basic problem, limited relevance	Problem unclear or irrelevant
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Literature Review (CO2) (10 marks)	Comprehensive, recent sources, critical analysis, gap identified	Adequate review with some analysis	Limited sources, mostly descriptive	Very poor or no literature review
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Clarity of Objectives (CO3) (10 marks)	Well-defined, measurable and achievable	Clear but partially measurable	Vague or broad objectives	Objectives not defined
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)

Rubrics for Interim Evaluation II (30 Marks)

Parameter	Excellent	Good	Average	Poor
Problem statement (CO1) (5 marks)	Clearly defined, relevant, innovative, aligned with real-world issues	Relevant but limited innovation	Basic problem, limited relevance	Problem unclear or irrelevant
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Literature Review (CO2) (5 marks)	Comprehensive, recent sources, critical analysis, gap identified	Adequate review with some analysis	Limited sources, mostly descriptive	Very poor or no literature review
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Methodology (CO3) (5 marks)	Well-structured, appropriate tools/techniques, justified	Suitable methodology with minor gaps	Basic methodology, limited justification	Inappropriate or unclear methodology
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)

Depth of Knowledge (CO2) (10 marks)	Strong conceptual and technical understanding	Good understanding with minor gaps	Basic understanding	Poor understanding
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Progress Achieved (CO3) (5 marks)	Significant progress with validated results	Moderate progress with partial results	Limited progress	Minimal orno progress
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)

Rubrics for Final Evaluation (25 Marks)

Parameter	Excellent	Good	Average	Poor
Relevance of problem statement (CO1) (5 marks)	Clearly defined, relevant, innovative, aligned with real-world issues	Relevant but limited innovation	Basic problem, limited relevance	Problem unclear or irrelevant
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Implementation of methodology (CO3) (5 marks)	Well-structured, appropriate tools/techniques, justified	Methodology implemented with minor gaps	Basic methodology, limited justification	Inappropriate or unclear methodology
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Knowledge & Involvement (CO4) (10 marks)	Demonstrates good understanding and active involvement throughout the project	Good understanding with consistent involvement	Basic understanding with moderate involvement	Poor understanding; minimal involvement
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Presentation& Viva (CO4) (5 marks)	Clear, confident, logical, excellent responses	Good presentation, answers most questions	Less communication, limited clarity	Poor communication, unable to answer
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)

Rubrics for Mini project report (10 Marks)

Parameter	Excellent	Good	Average	Poor
Technical Depth (CO4) (5 marks)	Comprehensive, well-analyzed content	Good technical content	Basic description	Poor/incomplete
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Organization & Format (CO4) (5 marks)	Well-structured, follows guidelines	Minor deviations	Inconsistent format	Poor structure
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)

SEMESTER III

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M26EE1M301	MOOC	MOOC	0	0	0	0	2

Preamble: A MOOC course of a minimum 8-week duration must be successfully completed before the end of the fourth semester (starting from Semester 1). The MOOC course shall be considered valid only if it is conducted by AICTE, NPTEL, SWAYAM, or NITTTR. The course must have a minimum duration of 8 weeks and should include syllabus content equivalent to at least 40 hours of teaching. Additionally, it must have a proctored/offline end-semester examination. Students may complete the MOOC course at their convenience but must do so before the end of the fourth semester. The Board of Studies (BoS) will provide a list of approved MOOC courses, provided that at least 70% of the course content aligns with the student's area or stream of study. However, a MOOC course will not be considered if more than 50% of its content overlaps with a core/elective course in the respective discipline or with an open elective. A credit of 2 will be awarded to students who successfully complete the MOOC course as per the evaluation criteria of the respective agency conducting the course.

LIST OF MOOC COURSES :

A. Power System Protection and Switch Gear

- Duration: 8 weeks
- Provider: NPTEL (IIT ROORKE)
- Course Content: The course for power system protection and switchgear.
- Relevance: It equips students bridges the gap between the theoretical advances, experimental validations and practical engineering in real life.

B. Power Quality

- Duration: 12 weeks
- Provider: NPTEL
- Course Content: This course is intended to provide tools to classify, quantify, and analyze the power quality problems and to provide practical engineering solutions to mitigate these problems.
- Relevance: It enables students to understand the concept of power and power factor in single-phase and three-phase systems supplying nonlinear loads. To understand the conventional compensation techniques used for power factor correction and load voltage regulation.

C. Advance Power Electronics and Control

- Duration: 8 weeks
- Provider: NPTEL(IIT ROORKE)
- Course Content: This course includes modern topics of Power Electronics in terms of switches, topologies and control..
- Relevance: It is highly relevant for students protection, help them to upgrade for the fast changing Power Electronics industry

D. Facts Devices

- Duration: 8 weeks
- Provider: NPTEL
- Course Content: FACTS is the acronym for Flexible AC Transmission Systems and refers to a group of resources used to overcome certain limitations in the static and dynamic transmission capacity of electrical networks.
- Relevance: The main purpose of these systems is to supply the network as quickly as possible with inductive or capacitive reactive power that is adapted to its particular requirements, while also improving transmission quality and the efficiency of the power transmission system.

E. Operation And Planning of Power Distribution Systems

- Duration: 12 weeks
- Provider: NPTEL (via SWAYAM)
- Course Content: This course will provide an overview of modern power distribution systems.
- Relevance: It enables students to design modelling of different types of distributed generation units and storage.

F. Power Quality Improvement Technique

- Duration: 8 weeks
- Provider: NPTEL
- Course Content: The course addresses the power quality of modern power distribution system is vulgarized due to the increased use of distributed sources, adjustable speed drive, nonlinear load and unbalanced load.

- Relevance: It equips students with essential skills to mitigation of the power quality problems produced by load disturbances and supply .

G. Fuzzy logic and neural networks

Duration: 8 weeks

- Provider: NPTEL
- Course Content: Fundamentals of neural networks and various learning methods will be discussed. The principles of multi-layer feed forward neural network, radial basis function network, self-organizing map, counter-propagation neural network, recurrent neural network, deep learning neural network will be explained with appropriate numerical examples
- Relevance: It is highly relevant for students, basic concepts of multi-layer feed forward neural network, radial basis function network, self-organizing map, counter-propagation neural network, recurrent neural network, deep learning neural network.

H. Basics of semiconductor microwave devices

- Duration: 12 weeks
- Provider: NPTEL
- Course Content This course will deal with semiconductor devices including diodes and transistors which are used in microwave and RF applications, especially for power amplifiers.
- Relevance:This course will seek to give a basic background of such devices in addition to conventional silicon LDMOS and bipolar devices. Toward the end, this course will also try to introduce basic microwave concepts from the device point-of-view.

I. Network Security

Duration: 12 weeks

- Provider: NPTEL
- Course Content: The goals of the field of network security are to understand how malicious users can attack networks, and design mechanisms for defending networks against such attacks.
- Relevance: The objective of the proposed course “Network Security” is to provide a detailed exposure to this important field to students. The course will include hands-on demonstration sessions.

J. Digital Electronic Circuits

- Duration: 12 weeks
- Provider: NPTEL
- Course Content: The course focuses on course is aimed at developing a deep understanding of digital electronic circuits. A signal can be discreet by nature whereas, a continuous signal can be discretized for digital processing and then converted back.
- Relevance: It equips students able to analyze and synthesize different kind of combinatorial and sequential digital systems for real-world use.

K. Power system protection

- Duration: 12 weeks
- Provider: NPTEL (IIT KHARAGPUR)
- Course Content: This course will cover up-to-date technology in the field emphasizing the current practice in Indian systems and also make aware of the current challenges.
- Relevance: It enables students to design different types of distributed generation units and storage.

L. Digital Protection of Power Systems

- Duration: 8 weeks
- Provider: NPTEL
- Course Content: This course focuses on the analytical techniques used in digital relays and application of PMUs in easily comprehensible manners so that academicians and particularly new beginners would not find any difficulty.
- Relevance: It provides students with provides a theoretical summary along with examples of real-life engineering applications to a variety of technical problems such as load shedding and frequency relaying, reclosing and synchronizing and protection issues.

M. Transducers for Instrumentation

- Duration: 12 weeks
- Provider: NPTEL
- Course Content: This course is designed with an aim to make students familier with the working principle of different types of sensors and transducers.
- Relevance: The students will have an exposure to basic physics of the sensors and their

importance in the real-world applications.

N. Design of power electronics converter

- Duration: 8 weeks
- Provider: NPTEL
- Course Content: In this course, students will learn the important concepts needed to design proper power electronic hardware, simulation tools, proper designing of power PCB, designing magnetics, reducing electromagnetic interference etc
- Relevance: It equips students should be able to design and test any power electronic converter on their own.

O. Applied Linear Algebra

Duration: 12 weeks

- Provider: NPTEL
- Course Content: The course will be directed towards training students in the art of proving and/or disproving assertions and also developing critical thinking abilities in the subject.
- Relevance: The course should be particularly useful to graduate students (masters and PhD students) who endeavor to solve theoretical problems in control theory, machine intelligence, data science, signal processing and related areas.

P. Advances in UHV Transmission and Distribution

- Duration: 8 weeks
- Provider: NPTEL (IISc Banglore)
- Course Content: This course emphasizes learning and understanding the newer design criteria required for the UHV transmission systems viz: insulation design, protections, safety concerns.
- Relevance: It is highly relevant for students to know various components on UHV transmission, design considerations for UHV substations

Q. Biophotonics

- Duration: 12 weeks
- Provider: NPTEL (via SWAYAM)
- Course Content: Biophotonics is a multidisciplinary field where light-based technologies

are utilized to reveal biological mechanisms, and diagnose several diseases along with finding their treatments.

- Relevance: This course introduces the basics of biology and photonics, and provides the most relevant and important application from chemistry, biology, and medicine. For examples, it includes how to detect and identify new viruses (such as the Coronavirus) and how to measure neural activities in live mouse.

R. Charging Infrastructure

- Duration: 12 weeks
- Provider: NPTEL (IIT Roorkee)
- Course Content: This course focuses on the key components of the charging infrastructure available for electric vehicles and its challenges. The course includes the discussion related to the various building blocks of EV charging systems such as power conversion unit and its associated communication (to exchange various data between the vehicle and electric vehicle supply equipment).
- Relevance:It intended to expose the students to the protocols, charging procedures and associated communication for AC and DC charging with a special focus on AC type-2 and DC CCS2 charging.

Slot	Course Code	Course	Category	Marks		L-T-P-S	Hours	Credit
				CIE	ESE			
K	M26EE1I302	INTERNSHIP	Internship	50	50	—	-	10

Internship - mandatory internship of minimum 16 weeks duration

Internships are educational and career development opportunities, providing practical experience in a field or discipline. They are structured, short-term, supervised placements often focused around particular tasks or projects with defined time scales. An internship may be compensated or non-compensated by the organization providing the internship. The internship has to be meaningful and mutually beneficial to the intern and the organization. It is important that the objectives and the activities of the internship program are clearly defined and understood. The internship offers th e students an opportunity to gain hands-on industrial or organizational exposure; to integrate the knowledge and skills acquired through the coursework; interact with professionals and other interns; and to improve their presentation, writing, and communication skills. Internship often acts as a gateway for final placement for many students.

A student shall opt for carrying out the Internship at an Industry/Research Organization or at another institute of higher learning and repute (Academia). The organization for Internship shall be selected/decided by the students on their own with prior approval from the faculty advisor/respective PG Programme Coordinator/Guide/Supervisor. Every student shall be assigned an internship Supervisor/Guide at the beginning of the Internship. The training shall be related to their specialization after the second semester for a minimum duration of 16 weeks. On completion of the course, the student is expected to be able to develop skills in facing and solving the problems experiencing in the related field.

Objectives

- Exposure to the industrial environment, which cannot be simulated in the classroom and hence creating competent professionals for the industry.
- Provide possible opportunities to learn understandand sharpen the real timetechnical / managerial skills required at the job.
- Exposure to the current technological developments relevant to the subject area of training.
- Create conducive conditions with quest for knowledge and its applicability on the job.
- Understand the social, environmental, economic and administrative considerations that influence the working environment.
- Expose students to the engineer's responsibilities and ethics.

Benefits of Internship

Benefits to Students

- An opportunity to get hired by the Industry/ organization.
- Practical experience in an organizational setting & Industry environment.
- Excellent opportunity to see how the theoretical aspects learned in classes are integrated into the practical world. On-floor experience provides much more

Professional experience which is often worth more than classroom teaching.

- Helps them decide if the industry and the profession is the best career option to pursue.
- Opportunity to learn new skills and supplement knowledge.
- Opportunity to practice communication and teamwork skills.
- Opportunity to learn strategies like time management, multi-tasking etc in an industrial setup.
- Makes a valuable addition to their resume.
- Enhances their candidacy for higher education/placement.
- Creating network and social circle and developing relationships with industry people.
- Provides opportunity to evaluate the organization before committing to a full time position.

Benefits to the Institute

- Build industry academia relations.
- Makes the placement process easier.
- Improve institutional credibility & branding.
- Helps in retention of the students.
- Curriculum revision can be made based on feedback from Industry/students.
- Improvement in teaching learning process.

Benefits to the Industry

- Availability of ready to contribute candidates for employment.
- Year round source of highly motivated pre-professionals.
- Students bring new perspectives to problem solving.
- Visibility of the organization is increased on campus.
- Quality candidate's availability for temporary or seasonal positions and projects.
- Freedom for industrial staff to pursue more creative projects.
- Availability of flexible, cost-effective workforce not requiring a long term employer commitment.
- Proven, cost-effective way to recruit and evaluate potential employees.
- Enhancement of employer's image in the community by contributing to the educational enterprise.

Types of Internships

- Industry Internship with/without Stipend
- Govt / PSU Internship (BARC/Railway/ISRO etc)
- Internship with prominent education/research Institutes
- Internship with Incubation centres /Start-ups

Guidelines

- All the students need to go for internship for minimum duration of 16 weeks.
- Students can take mini projects, assignments, case studies by discussing it with concerned authority from industry and can work on it during internship.
- All students should compulsorily follow the rules and regulations as laid by industry.
- Every student should take prior permissions from concerned industrial authority if they want to use any drawings, photographs or any other document from industry.
- Student should follow all ethical practices and SOP of industry.
- Students have to take necessary health and safety precautions as laid by the industry.
- Student should contact his /her Guide/Supervisor from college on weekly basis to

communicate the progress.

- Each student has to maintain a diary/log book
- After completion of internship, students are required to submit
- Report of work done
- Internship certificate copy
- Feedback from employer / internship mentor
- Stipend proof (in case of paid internship).

Total Marks 100: The marks awarded for the Internship will be on the basis of (i) Evaluation done by the Industry (ii)) Internal evaluation & Student's diary (iii) Internship Report and (iv) Comprehensive Viva Voce.

Continuous Internal Evaluation: 50 marks

Internal evaluation & Student's diary	:	25 Marks
Evaluation done by the Industry	:	25 Marks

Internal evaluation committee comprises of Programme coordinator, Project coordinator and a senior faculty.

Student's Diary/ Daily Log: The main purpose of writing daily diary is to cultivate the habit of documenting and to encourage the students to search for details. It develops the students' thought process and reasoning abilities. The students should record in the daily training diary the day to day account of the observations, impressions, information gathered and suggestions given, if any. It should contain the sketches & drawings related to the observations made by the students. The daily training diary should be signed after every day by the supervisor/ in charge of the section where the student has been working. The diary should also be shown to the Faculty Mentor visiting the industry from time to time and got ratified on the day of his visit. Student's diary will be evaluated on the basis of the following criteria:

- Regularity in maintenance of the diary
- Adequacy & quality of information recorded
- Drawings, design, sketches and data recorded
- Thought process and recording techniques used
- Organization of the information.

The format of student's diary

Name of the Organization/Section:

Name and Address of the Section Head:

Name and Address of the Supervisor:

Name and address of the student:

Internship Duration: From ……..…… To ……..

Brief description about the nature of internship:

Day	Brief write up about the Activities carried out: Such as design,sketches, result observed, issues identified, data recorded, etc.
1	
2	
3	

Signature of Industry Supervisor *Signature of Section Head/HR Manager*

Attendance Sheet

Name of the Organization/Section:

Name and Address of the Section Head:

Name and Address of the Supervisor:

Name and address of the student:

Internship Duration: From ……To ……..

Month& Year		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	...
Month& Year																						
Month& Year																						

Signature of Industry Supervisor *Signature of Section Head/HR Manager*

Note:

- Student's Diary shall be submitted by the students along with attendance record and an evaluation sheet duly signedand stamped by the industry to the Institute immediately after the completion of the training.
- Attendance Sheet should remain affixed in daily training diary. Do not remove

or tearit off.

- Student shall sign in the attendance column. Do not mark 'P'.
- Holidays should be marked n red inkin the attendance column. Absent should be marked as 'A' in red ink.

Evaluation done by the Industry (Marks 25)

Format for Supervisor Evaluation of Intern

Student Name :_____Date:__Supervisor Name:_____Designation:____
_____Company/Organization :_____
Internship Address: _____Dates of Internship: From_____To_____

Please evaluate intern by indicating the frequency withwhich youobserved following parameters:

Parameters	**Marks** Rating (0-10mark)
Behavior	
Performs in adependable Manner	
Cooperates withcoworkers and supervisor	
Shows interest in work	
Learns quickly	
Shows initiative	
Produces high quality work	
Accepts responsibility	
Accepts criticism	
Demonstrates organizational skills	
Uses technical knowledgeand expertise	
Shows good judgment	
Demonstrates creativity/originality	
Analyzes problems effectively	
Is self-reliant	
Communicates well	
Writes effectively	
Has a professional attitude	
Is punctual	
Uses time effectively	

Overall performance of student:
Intern (Tick one): Needs improvement (0–1 mark) / Satisfactory (2 mark) / Good (3 mark) / Very Good (4 mark) / Excellent (5 mark)
Additional comments, if any:

Signature of Industry Supervisor *Signature of Section Head/HR Manager*

End Semester Evaluation (External Evaluation) : 50 Marks

Internship Report : 25 Marks
Viva Voce : 25 Marks

Internship Report: After completion of the internship, the student should prepare a comprehensive report to indicate what he has observed and learnt in the training period and should be submitted to the faculty Supervisor. The student may contact Industrial Supervisor/ Faculty Mentor for assigning special topics and problems and should prepare the final report on the assigned topics. Daily diary will also help to a great extent in writing the industrial report since much of the information has already been incorporated by the student into the daily diary. The training report should be signed by the Internship Supervisor, Programme Coordinator and Faculty Mentor.
The Internship report (25 Marks) will be evaluated on the basis of following criteria:

- Originality
- Adequacy and purposeful write-up
- Organization, format, drawings, sketches, style, language etc.
- Variety and relevance of learning experience
- Practical applications, relationships with basic theory and concepts taught in the course

Viva Voce (25 Marks) will be done by a committee comprising Project coordinator, Programme Coordinator and an external expert (from Industry or research/academic Institute). This committee will be evaluating the internship report also.

Rubrics for Students diary and Internal Evaluation (25 Marks)

Parameter	Excellent	Good	Average	Poor
Regularity & Completeness (5 marks)	Diary maintained regularly with complete and consistent entries	Mostly regular with minor gaps	Irregular entries; some missing records	Rarely maintained; major gaps
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Application of Concepts (5 marks)	Strong real-world application	Moderate application	Limited application	No application

Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Understanding of Work (5 marks)	Thorough understanding, confident	Good understanding	Basic knowledge	Poor understanding
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Organization & Clarity (5 marks)	Well-structured, clearand logical	Minorissues in organization	Poor structure	Disorganized
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Presentation skills (5 marks)	Clearand well structured	Good presentation	Average clarity	Poor communication
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)

Rubrics for External Evaluation (Viva Voce) (25 Marks)

Parameter	**Excellent**	**Good**	**Average**	**Poor**
Understanding of Work (10 marks)	Thorough understanding, confident	Good understanding	Basic knowledge	Poor understanding
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Integration with theory (5 marks)	Strong linkage with academic concepts	Moderate linkage	Weak linkage	No linkage
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Application of Concepts (5 marks)	Strong real-world application	Moderate application	Limited application	No application
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Presentation skills (5 marks)	Clearand well structured	Good presentation	Average clarity	Poor communication
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)

Rubrics for Internship report (25 Marks)

Parameter	Excellent	Good	Average	Poor
Technical Depth (10 marks)	Comprehensive, well-analyzed, industry relevance	Good technical content	Basic description	Poor/ incomplete
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Organization & Format (10 marks)	Well-structured, follows guidelines	Minor deviations	Inconsistent format	Poor structure
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Originality (5 marks)	Highly original work	Some originality	Limited originality	Copied/ plagiarized
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)

Slot	Course Code	Course	Category	Marks		L-T-P-S	Hours	Credit
				CIE	ESE			
P	M26EE1P303	DISSERTATION PHASE I	Project	100	—	0-0-12-18	12	8

Dissertation Phase I may be undertaken either in the college or in the industry. Dissertation Phase I can be linked with internship. Such students are expected to have the following skills: Technical Skills, Research Skills, Communication Skills, Critical Thinking Skills, and Problem-Solving Skills.

Objectives

The objectives of M.Tech Dissertation Phase 1 typically focus on laying a strong foundation for the research work to be conducted in subsequent phases. While specific objectives can vary depending on the institution, discipline, and project, the following are common goals for Phase 1:

1. **Topic Identification and Selection**: To identify a relevant, feasible, and innovative research topic aligned with the student's area of interest and the field's current trends or challenges.
2. **Literature Review**: To conduct a preliminary review of existing research and literature to understand the state of the art, identify gaps, and establish the context for the proposed work.
3. **Problem Definition**: To dearly define the research problem or question that the dissertation aims to address, ensuring it is specific, measurable, and researchable.
4. **Objective Formulation**: To establish clear and achievable objectives for the overall dissertation, outlining what the research intends to accomplish.
5. **Feasibility Assessment**: To evaluate the practicality of the proposed research in terms of available resources, time constraints, and technical requirements.
6. **Methodology Outline**: To develop a preliminary plan for the research methodology, including the tools, techniques, or approaches that will be used to investigate the problem.
7. **Synopsis Preparation**: To prepare and submit a concise synopsis or proposal summarizing the research topic, objectives, significance, and planned approach for approval by the academic supervisor or committee.
8. **Background Knowledge Building**: To deepen the student's understanding of the chosen domain and related concepts, ensuring a solid theoretical foundation for the research.

These objectives are designed to set the stage for Phase 2 and beyond, where the focus typically shifts to implementation, experimentation, and analysis. Phase 1 is critical for ensuring that the research is well-planned and directed toward a meaningful contribution to the field.

Course Outcome

After completing dissertation phase 1 student should be able to

CO1: Demonstrate **Research Topic Selection Skills**: Students will be able to identify and select a research topic that is innovative, relevant, and feasible within the scope of their M.Tech program.

CO2: Conduct **Effective Literature Analysis**: Students will develop the ability to critically review and synthesize existing literature to identify research gaps and establish the context for their study.

CO3: Define **a Clear Research Problem , formulate objectives and methodology**: Students will acquire the skill to articulate a well-defined research problem or question, ensuring it is specific, measurable, and aligned with their dissertation goals.

CO4: Prepare **a Comprehensive Research Proposal**: Students will gain the capability to create a structured synopsis or proposal, effectively communicating the significance, objectives, and planned approach of their research for evaluation.

Course Outcome (CO)	Mapped Program Outcome (PO)	Justification
CO1: Demonstrate Research Topic Selection Skills	PO1: Ability to independently carry out research/investigation and development work	Selecting a research topic requires independent exploration and judgment, aligning with research skills.
	PO3: Demonstrate mastery over the specialization area	Topic selection reflects an understanding of advanced concepts beyond undergraduate level.
CO2: Conduct Effective Literature Analysis	PO1: Ability to independently carry out research/investigation and development work	Literature analysis is a core research skill, requiring Independent critical thinking.
	PO3: Demonstrate mastery over the specialization area	Analyzing literature demonstrates depth of Knowledge in the chosen field.
CO3: Define a Research Problem, formulate objectives and methodology	PO1: Ability to independently carry out research/investigation and development work	Defining a research problem is a fundamental step in independent research.
	PO4: Apply stream knowledge to design or develop solutions for real-world problems	A well-defined problem often addresses real-world challenges using specialized knowledge.
	PO5: Identify, select, and apply appropriate techniques, resources, and tools	Outlining methodology involves selecting suitable techniques and tools for the research.
CO4: Prepare a Comprehensive Research Proposal	PO2: Ability to communicate effectively, write and present technical reports	Writing a proposal requires clear communication and presentation skills for technical audiences.
	PO6: Engage in life-long learning with consideration of sustainability, societal aspects	A proposal often reflects awareness of broader impacts, fostering

Continuous Internal Evaluation

Evaluation committee comprises of

1. Project coordinator

2. A senior faculty
3. Project supervisor / Industry mentor

Course Outcome (CO)	Marks Allocated	Justification
CO1: Demonstrate Research Topic Selection Skills	25	Topics election is foundational but less intensive than later stages; it requires creativity and initial research.
CO2: Conduct Effective Literature Analysis	25	Literature review is critical, time-intensive, and requires critical thinking to identify gaps.
CO3: Define a Clear Research Problem; formulate objectives and Methodology	25	Defining the problem is a pivotal step, requiring clarity and alignment with research goals; formulating objectives and methodology demands detailed planning and technical understanding
CO4: Prepare a Comprehensive Research Proposal	25	Proposal preparation integrates all prior work in to a concise document, focusing on communication
Total	**100**	

Detailed Breakdown and Rationale:

1. **CO1: Demonstrate Research Topic Selection Skills (25 marks)**
   - This involves identifying a feasible and innovative topic. It's an essential starting point but less complex than subsequent analytical tasks.
   - Assessment: Relevance, originality, and feasibility of the topic.
2. **CO2: Conduct Effective Literature Analysis (25 marks)**
   - A thorough literature review is a corner stone of Phase 1, requiring significant effort to survey existing work, analyze gaps, and establish context.
   - Assessment: Depth, breadth, and critical evaluation of sources.
3. **CO3: Define a Clear Research Problem, formulate objectives and methodology (25 marks)**
   - Involves defining a clear and specific research problem and formulating objectives and methodology, requiring critical thinking, planning, and technical understanding as it sets the direction for the dissertation.
   - Assessment: Clarity, specificity, and significance of the problem statement.
4. **CO4: Prepare a Comprehensive Research Proposal (25 marks)**
   - The proposal synthesizes all prior work into a structured document. While important for communication, it's less intensive than analysis or planning, hence a slightly lower weight.
   - Assessment: Structure, clarity, and completeness of the proposal.

M.Tech Dissertation Phase 1 (Industry-Based)

Overview

- **Target Students**: Those who have completed a long-term internship(≥16 weeks) and aim to conduct their dissertation in industry.

- **Focus**: In-depth research, industry-relevant problem-solving, and collaboration with industrial mentors.
- **Total Marks**: 100 (for Phase 1).

Evaluation Process

- **Industry Mentor Involvement**: The industry mentor (from the internship or dissertation site) provides feedback and assesses feasibility.
- **Academic Supervisor**: Ensures academic rigor and alignment with M.Tech standards.
- **Expert Committee Review**: Evaluates the final proposal.
- **Deliverables**:
  - Interim report (literature review, problem statement) – Mid-Phase 1.
  - Final proposal (synopsis) – End of Phase 1.

Evaluation of Dissertation Phase I

Rubrics for Zeroth presentation (30 Marks)

Parameter	Excellent	Good	Average	Poor
Topic Selection (10 marks) (CO1)	Relevant to current research/industry, strong SDG alignment	Relevant with some novelty	Limited relevance	Irrelevant/unclear
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Literature Review & Analysis (10 marks) (CO2)	Comprehensive, recent, critically analyzed; clear research gap	Adequate review with some analysis	Limited, descriptive	Poor/no review
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Problem Definition (5 marks) (CO3)	Clearly defined, specific, research-worthy	Defined but lacks depth	Vague or broad	Not defined
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Presentation & Communication (5 marks) (CO4)	Highly clear, logical, confident delivery	Good clarity	Basic clarity	Poor communication
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)

Rubrics for Interim presentation (30 Marks)

Parameter	Excellent	Good	Average	Poor
Relevance of Topic (5marks) (CO1)	Highly innovative, relevant to current research/industry, strong SDG alignment	Relevant with some novelty	Limited relevance	Irrelevant/unclear
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Literature Review & Analysis (10 marks) (CO2)	Comprehensive, recent, critically analyzed; clear research gap	Adequate review with some analysis	Limited, descriptive	Poor/no review
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Objectives & Methodology (10 marks) (CO3)	Well-defined objectives; robust, feasible, justified methodology	Suitable with minor gaps	Basic methodology	Inappropriate/ missing
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Progress Achieved (5 marks) (CO4)	Significant progress with validated results	Moderate progress with partial results	Limited progress	Minimal or no progress
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)

Rubrics for Final presentation (College based) (40Marks)

Parameter	Excellent	Good	Average	Poor
TopicSelection& Novelty (10 marks) (CO1)	Topic is highly relevant, innovative, and aligned with current research/ industry needs; clear	Topic is relevant with some degree of novelty; partial alignment with current trends	Topic is basic with limited originality; minimal relevance to current trends	Topic is outdated, irrelevant, or lacks clarity; no evidence of novelty

	demonstration of originality			
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Literature Review & Analysis (5 marks) (CO2)	Comprehensive, recent, critically analyzed; clear research gap	Adequate review with some analysis	Limited, descriptive	Poor/no review
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Definition of Research Problem, Formulation of Research (10 marks) (CO3)	Problem is clearly defined, Objectives are clear, measurable, and research-worthy; well-justified with appropriate tools/techniques	Problem is defined and relevant, Objectives are clear; methodology is suitable with minor gaps in justification	Problem is vague, Objectives are basic or partially aligned; methodologyis limited or lacks clarity	Problem and objectives are unclear, irrelevant, or not defined
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Report (10 marks) (CO4)	Well-structured, technically sound, excellent clarity, proper references	Good documentation with minor issues	Average documentation	Poor/ incomplete
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Presentation & Communication (5 marks) (CO4)	Highly clear, logical, confident delivery	Good clarity	Basic clarity	Poor communication
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)

Rubrics for Final presentation (Industry based) (40 Marks)

Parameter	Excellent	Good	Average	Poor
TopicSelection& Novelty (10 marks) (CO1)	Topic is highly relevant, innovative, and aligned with current research/ industry needs; clear demonstration of originality	Topic is relevant with some degree of novelty; partial alignment with current trends	Topicis basic with limited originality; minimal relevance to current trends	Topic is outdated, irrelevant, or lacks clarity; no evidence of novelty
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Literature Review & Analysis (5 marks) (CO2)	Comprehensive, recent, critically analyzed; clear research gap	Adequate review with some analysis	Limited, descriptive	Poor/no review
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Definition of Research Problem, Formulation of Objectives (5 marks) (CO3)	Problem is clearly defined, Objectives are clear, measurable, and research-worthy; well-justified with appropriate tools/techniques	Problem is defined and relevant, Objective sare clear; methodology is suitable with minor gaps in justification	Problem is vague, Objectives are basic or partially aligned; methodology is limited or lacks clarity	Problem and objectives are unclear, irrelevant, or not defined
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
*Feedback from industry (5 marks) CO3)	Excellent	Good	Satisfactory	Needs improvement
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Report (10 marks) (CO4)	Well-structured, technically sound, excellent clarity, proper references	Good documentation with minor issues	Average documentati on	Poor/ incomplete
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)

Presentation & Communication (5 marks) (CO4)	Highly clear, logical, confident delivery	Good clarity	Basic clarity	Poor communication
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)

*Feedback from industry may be taken in 5-point scale

Feedback from Industry (Marks 25)

Format for Supervisor Evaluation of Intern

Student Name :_____Date:__Supervisor Name:_____Designation:____

_____Company/Organization :_____

Internship Address:_____Dates of Internship: From_____To_____

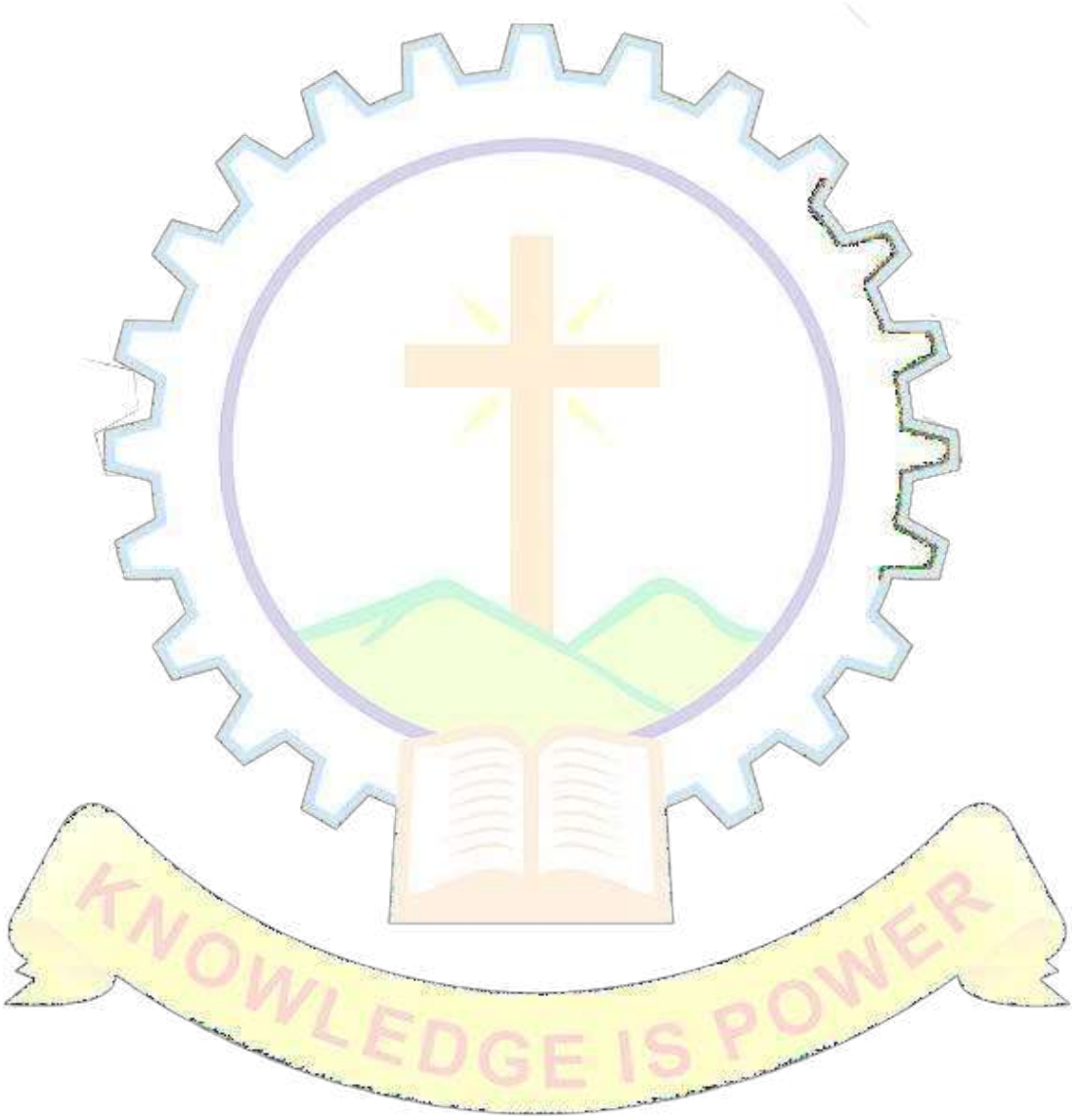
Please evaluate intern by indicating the frequency with which you observed following parameters:

Parameters	**Marks** Rating (0-10mark)
Behavior	
Performs in a dependable Manner	
Cooperates with coworkers and supervisor	
Shows interest in work	
Learns quickly	
Shows initiative	
Produces high quality work	
Accepts responsibility	
Accepts criticism	
Demonstrates organizational skills	
Uses technical knowledge and expertise	
Shows good judgment	
Demonstrates creativity/originality	
Analyzes problems effectively	
Is self-reliant	
Communicates well	
Writes effectively	
Has a professional attitude	
Is punctual	
Uses time effectively	

Overall performance of student:

Intern (Tick one): Needs improvement (0–1 mark) / Satisfactory (2 mark) / Good (3 mark) / V e ry Good (4 mark) / Excellent (5 mark)
Additional comments, if any:

Signature of Industry Supervisor *Signature of Section Head/HR Manager*



SEMESTER IV

Slot	Course Code	Course	Category	Marks		L-T-P-S	Hours	Credit
				CIE	ESE			
P	M26EE1P401	DISSERTATION PHASE II	Project	100	100	0-0-24-26	24	20

- **Duration**: Typically the final semester (e.g., fourth semester of M.Tech).
- **Focus**: Implementation, experimentation, analysis, and conclusion of the research initiated in Phase 1.
- **Common Objectives**:
    1. Execute the proposed methodology.
    2. Analyze results and draw meaningful conclusions.
    3. Demonstrate technical proficiency and problem-solving.
    4. Document and present findings effectively.

Scheme for Dissertation Phase II (College-Based)

Course Outcomes (COs)

1. **CO1**: Implement the research methodology proposed in Phase 1 using appropriate tools and techniques (Technical Skills, Problem-Solving Skills).
2. **CO2**: Conduct experiments or simulations to generate data or validate the approach (Research Skills, Critical Thinking Skills).
3. **CO3**: Analyze results and interpret findings to address the research problem (Critical Thinking Skills, Research Skills).
4. **CO4**: Prepare a comprehensive dissertation report that systematically documents the research process, outcomes, and effectively present the work (Communication Skills, Technical Skills).

Evaluation Scheme

1. **Continuous Internal Evaluation (CIE) – 100 Marks**
    - Assessed by the project coordinator throughout the semester.
    - Focus: Progress, effort, and intermediate deliverables.

Paper publication/acceptance (10 marks): Awarded only if at least one paper (authored by the student) is published or accepted in:

- A recognized national/international conference or,
- An indexed journal
- Proof required: Acceptance letter/publication link/DOI/conference proceedings page

Component	Marks	CO Assessed	Justification
Methodology Implementation Progress	25	CO1	Monitors execution of the proposed plan in a college lab or simulation setup.
Experimental/Simulation Work	25	CO2	Assesses data collection or validation efforts in a controlled academic setting.
Interim Result Analysis	25	CO3	Evaluates preliminary analysis and critical thinking during the semester.

Draft Report Submission, Presentation	25	CO4	Checks documentation quality and adherence to academic standards; assesses communication and ability to discuss progress with the supervisor.
Total	**100**		

Rubrics for Interim Presentation I (30 marks)

Parameter	**Excellent**	**Good**	**Average**	**Poor**
Implementation of Methodology (10 marks) (CO1)	Methodology implemented	Implementation initiated with good progress	Partial implementation with limited clarity	No meaningful progress
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Experimental/ Analytical Work (10 marks) (CO2)	Results are well-validated and critically analyzed	Results interpreted with some validation	Basic interpretation	No meaningful interpretation
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Validation & Interpretation of Results (5 marks) (CO3)	Strong validation with comparison and justification	Adequate validation	Limited validation	No validation
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Presentation& Viva (5 marks) (CO4)	Excellent communication and defense	Good communication	Average	Poor
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)

Rubrics for Interim Presentation II (30 marks)

Parameter	**Excellent**	**Good**	**Average**	**Poor**
Execution of the Proposed Methodology (5 marks) (CO1)	Complete, accurate, well-executed	Minor gaps in execution/accuracy	Partially complete, limited accuracy	Incomplete, incorrect implementation
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Progress Achieved (5 marks) (CO2)	Significant progress with validated results	Moderate progress with partial results	Limited progress	Minimal or no progress
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)

Quality of Results/Data & Analysis (5 marks) (CO3)	Robust results, deep analysis, strong conclusions	Good results, adequate analysis	Basic results, limited analysis	Weak/invalid results, poor analysis
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Depth of Knowledge (5 marks) (CO3)	Strong conceptual and technical understanding	Good understanding with minor gaps	Basic understanding	Poor understanding
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
PresentationSkills (5 marks) (CO4)	Highly professional and confident	Good	Average	Poor
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)

Rubrics for Final Internal Presentation (40 marks)

Parameter	Excellent	Good	Average	Poor
Proposed Methodology (10 marks) (CO1)	Complete, accurate, well-executed	Minor gaps in execution/ accuracy	Partially complete, limited accuracy	Incomplete, incorrect implementation
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Understanding of Work (10 marks) (CO2)	Thorough understanding, confident	Good understanding	Basic knowledge	Poor understanding
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Validation & Results (10 marks) (CO3)	Strong validation with comparison and justification	Adequate validation	Limited validation	No validation
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Report (10 marks) (CO4)	Excellent technical report with proper structure and references	Good clarity	Basic clarity	Poor communication
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)

Presentationskill (5 marks) (CO4)	Clear& confident presentation	Good communication	Average	Poor
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)

2. **End Semester Evaluation (ESE) – 100 Marks**
   - Assessed by a panel (Project coordinator+ supervisor + external examiner) at the semester's end.
   - Focus: Final output, rigor, and presentation.

Component	Marks	CO Assessed	Justification
Final Methodology Implementation	25	CO1	Evaluates completeness and technical accuracy of the implemented solution.
Quality of Results/Data, Depth of Analysis and Conclusions	30	CO2	Assesses the robustness and validity of experimental or simulation outcomes, examines the interpretation and significance of findings.
Final Dissertation Report	20	CO3	Judges the quality, structure, and clarity of the written report.
Viva Voce/Presentation	25	CO4	Tests ability to defend work and communicate findings to an academic panel.
Total	**100**		

Rubrics for End Semester Evaluation

Parameter	Excellent	Good	Average	Poor
Methodology Implementation (25 marks) (CO1)	Complete, accurate, well-executed	Minor gaps in execution/accuracy	Partially complete, limited accuracy	Incomplete, incorrect implementation
Range of marks	(20-25 marks)	(15-19 marks)	(10-14 marks)	(0-9 marks)
Quality of Results/Data & Analysis (30 marks) (CO2)	Robust results, deep analysis, strong conclusions	Good results, adequate analysis	Basic results, limited analysis	Weak/invalid results, poor analysis
Range of marks	(25-30 marks)	(20-24 marks)	(10-19 marks)	(0-9 marks)

Dissertation Report (20 marks) (CO3)	Clear, well-structured, high quality	Good structure with minorissues	Adequate but lacks clarity/flow	Poorly written, unstructured
Range of marks	(15-20 marks)	(10-14 marks)	(5-9 marks)	(0-4 marks)
Viva Voce / Presentation (25 marks) (CO4)	Confident, clear, presentation with in-depth knowledge	Clear with minor gaps	Basic explanation, weak defense	Unclear, unable to defend
Range of marks	(20-25 marks)	(15-19 marks)	(10-14 marks)	(0-9 marks)

Scheme for Dissertation Phase II (Industry-Based)

Course Outcomes (COs)

1. **CO1**: Implement the industry-oriented methodology proposed in Phase 1 using industry tools/resources (Technical Skills, Problem-Solving Skills).
2. **CO2**: Perform industry-relevant experiments, validations, or prototypes (Research Skills, Critical Thinking Skills).
3. **CO3**: Analyze results and draw conclusions applicable to the industry problem (Critical Thinking Skills, Research Skills).
4. **CO4:** Prepare a comprehensive dissertation report that systematically documents the research process and outcomes, and effectively present and defend the work before an academic audience (Communication Skills, Technical Skills).Evaluation Scheme

1. **Continuous Internal Evaluation (CIE) – 100 Marks**
   - Assessed jointly by the Project coordinator, supervisor / industry mentor during the semester.
   - Focus: Industry collaboration, progress, and practical application.

Component	Marks	CO Assessed	Justification
Methodology Implementation Progress	25	CO1	Tracks execution of the plan in an industry environment using real-world tools.
Industry Validation/Prototype Work, result Analysis	30	CO2	Evaluates practical outputs (e.g., prototypes, tests) relevant to industry needs, assesses industry-applicable insights derived during the process.
Draft Report Submission	20	CO3	Ensures documentation meets both academic and industry standards.
Industry Feedback/Interaction	25	CO4	Gauges communication with industry mentor and progress updates.
Total	**100**		

Rubrics for Internal Evaluation (100 marks)

Parameter	Excellent	Good	Average	Poor
Methodology Implementation (25 marks) (CO1)	Systematic, on-time, effective use of tools	Good progress, minor gaps	Partial progress, some delays	Poor progress, inadequate execution
Range of marks	(20-25 marks)	(15-19 marks)	(10-14 marks)	(0-9 marks)
Industry Validation / Prototype & Analysis (30 marks) (CO2)	High-quality validation, deep analysis, strong relevance	Good validation and analysis	Basic validation, limited analysis	No meaningful validation or analysis
Range of marks	(25-30 marks)	(20-24 marks)	(10-19 marks)	(0-9 marks)
Draft Report (20 marks) (CO3)	Clear, structured, comprehensive	Good with minor issues	Adequate, lacks depth/clarity	Poor, incomplete, unstructured
Range of marks	(15-20 marks)	(10-14 marks)	(5-9 marks)	(0-4 marks)
Industry Feedback / Interaction (25 marks) (CO4)	Proactive, regular updates, effective feedback use	Good interaction, periodic updates	Limited interaction, partial feedback use	Poor communication, no feedback use
Range of marks	(20-25 marks)	(15-19 marks)	(10-14 marks)	(0-9 marks)

Feedback from Industry (Marks 25)

Format for Supervisor Evaluation of Intern

Student Name :_____Date:__Supervisor Name:_____Designation:____
_____Company/Organization :_____

Internship Address:_____Dates of Internship: From_____To_____

Please evaluate intern by indicating the frequency with which you observed following parameters:

Parameters	Marks Rating (0-10mark)
Behavior	
Performs in a dependable Manner	
Cooperates with coworkers and supervisor	
Shows interest in work	

Learns quickly	
Shows initiative	
Produces high quality work	
Accepts responsibility	
Accepts criticism	
Demonstrates organizational skills	
Uses technical knowledge and expertise	
Shows good judgment	
Demonstrates creativity/originality	
Analyzes problems effectively	
Is self-reliant	
Communicates well	
Writes effectively	
Has a professional attitude	
Is punctual	
Uses time effectively	

Performance of student:

Intern (Tick one): Needs improvement (0–1 mark) / Satisfactory (2 mark) / Good (3 mark) / V e ry Good (4 mark) / Excellent (5 mark)
Additional comments, if any:

Signature of Industry Supervisor *Signature of Section Head/HR Manager*

2. **End Semester Evaluation (ESE) – 100 Marks**
    - Assessed by a panel (Project coordinator, supervisor/industry mentor, external examiner).
    - Focus: Final deliverables, industry relevance, and dual-audience presentation.
    -

Component	Marks	CO Assessed	Justification
Final Methodology Implementation	25	CO1	Evaluates the technical success of the industry-implemented solution.
Quality of Industry Outputs/Results, depth of Analysis and Industry Impact	30	CO2	Assesses the practical utility and quality of industry-specific deliverables, examines conclusions and their relevance to industry challenges.
Final Dissertation Report	20	CO3	Judges the report's ability to address academic rigor and industry needs.
Viva Voce/Presentation (Dual Audience)	25	CO4	Tests communication to both academic and industry evaluators.
Total	**100**		

Rubrics for End Semester Evaluation (100 marks)

Parameter	Excellent	Good	Average	Poor
Methodology Implementation (25 marks) (CO1)	Innovative, well-executed, validated	Appropriate, minor gaps	Acceptable, limited depth/validation	Poor, unclear, or irrelevant
Range of marks	(20-25 marks)	(15-19 marks)	(10-14 marks)	(0-9 marks)
Results, Analysis & Industry Impact (30 marks) (CO2)	Highly relevant, deep analysis, strong impact	Relevant, good analysis	Limited relevance, basic analysis	Irrelevant, weak/no analysis
Range of marks	(25-30 marks)	(20-24 marks)	(10-19 marks)	(0-9 marks)
Final Dissertation Report (20 marks) (CO3)	Well-structured, clear, technically strong	Good structure, minor issues	Adequate, lacks clarity/depth	Poorly written, unstructured
Range of marks	(15-20 marks)	(10-14 marks)	(5-9 marks)	(0-4 marks)
Viva Voce / Presentation(25 marks) (CO4)	Confident, clear, presentation with in-depth knowledge	Clear with minor gaps	Basic, limited clarity	Unclear, unable to defend
Range of marks	(20-25 marks)	(15-19 marks)	(10-14 marks)	(0-9 marks)

EVALUATION COMMITTEES AT A GLANCE

MINI PROJECT (100 Marks) **Continuous Internal Evaluation (CIE) – 100 Marks** Evaluation committee comprises Project coordinator, senior faculty and Project supervisor. Final evaluation by a Committee of Project coordinator, Project supervisor and a senior faculty.
INTERNSHIP (100 Marks) **Internal evaluation committee (25 Marks)** comprises of Programme coordinator, Project coordinator and a senior faculty. **Viva Voce (25 Marks)** will be done by a committee comprising Programme Coordinator, Project coordinator and an external expert (from Industry or research/academic Institute)
DISSERTATION PHASE I (100 Marks) **Continuous Internal Evaluation (CIE) – 100 Marks** Evaluation committee comprises of Project coordinator, senior faculty and project supervisor / Industry mentor
DISSERTATION PHASE II (200 Marks) **Continuous Internal Evaluation (CIE) – 100 Marks** Assessed jointly by the Project coordinator, supervisor / industry mentor and senior faculty during the semester. **End Semester Evaluation (ESE) – 100 Marks** Assessed by a panel of Project coordinator, supervisor and external examiner at the semester end.