SCHOOL OF ELECTRICAL ENGINEERING

M. Tech Power Electronics and Drives

(M.Tech MPE)

Curriculum

(*2020-2021 admitted students*)

VISION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

Transforming life through excellence in education and research.

MISSION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

World class Education: Excellence in education, grounded in ethics and critical thinking, for improvement of life.

Cutting edge Research: An innovation ecosystem to extend knowledge and solve critical problems.

Impactful People: Happy, accountable, caring and effective workforce and students.

Rewarding Co-creations: Active collaboration with national & international industries & universities for productivity and economic development.

Service to Society: Service to the region and world through knowledge and compassion.

VISION STATEMENT OF THE SCHOOL OF ELECTRICAL ENGINEERING

To be a leader for academic excellence in the field of electrical, instrumentation and control engineering imparting high quality education and research leading to global competence for the societal and industrial developments.

MISSION STATEMENT OF THE SCHOOL OF ELECTRICAL ENGINEERING

- Impart high quality education and interdisciplinary research by providing conducive teaching learning environment and team spirit resulting in innovation and product development.
- Enhance the core competency of the students to cater to the needs of the industries and society by providing solutions in the field of electrical, electronics, instrumentation and automation engineering.
- Develop analytical skills, leadership quality and team spirit through balanced curriculum.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

1. Graduates will be engineering practitioners and leaders, who would help solve industry's technological problems.

2. Graduates will be engineering professionals, innovators or entrepreneurs engaged in technology development, technology deployment, or engineering system implementation in industry.

3. Graduates will function in their profession with social awareness and responsibility.

4. Graduates will interact with their peers in other disciplines in industry and society and contribute to the economic growth of the country.

5. Graduates will be successful in pursuing higher studies in engineering or management.

6. Graduates will pursue career paths in teaching or research.

M. Tech Power Electronics and Drives

PROGRAMME OUTCOMES (POs)

PO_01: Having an ability to apply mathematics and science in engineering applications.

PO_02: Having an ability to design a component or a product applying all the relevant standards and with realistic constraints

PO_03: Having an ability to design and conduct experiments, as well as to analyze and interpret data

PO_04: Having an ability to use techniques, skills and modern engineering tools necessary for engineering practice

PO_05: Having problem solving ability- solving social issues and engineering problems

PO_06: Having adaptive thinking and adaptability

PO_07: Having a clear understanding of professional and ethical responsibility

PO_08: Having a good cognitive load management [discriminate and filter the available data] skills

M. Tech Power Electronics and Drives

PROGRAMME SPECIFIC OUTCOMES (PSOs)

On completion of M. Tech. (Power Electronics and Drives) programme, graduates will be able to

- PSO1: Apply technical knowledge, skills and analytical ability to design, develop and test power electronic converters and drives using modern tools and technologies.

- PSO2: Solve the real world problems in the emerging fields like smart grid, renewable energy interfaces, and electric vehicles and to develop innovative technologies relevant to social, ethical, economic and environmental issues

- PSO3: Solve research gaps and provide solutions to socio-economic, and environmental problems.

M. Tech Power Electronics and Drives

CREDIT STRUCTURE

Category-wise Credit distribution

Credits Breakup	
	CREDITS
University Core	27
University Elective	6
Program Core	19
Program Elective	18
Total	70

VIT Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

M. Tech Power Electronics and Drives

DETAILED CURRICULUM

University Core

S. No.	Course Code	Course Title	L	T	P	J	C
1.	MAT5003	Methods of Applied Mathematics	3	0	0	0	3
2.	ENG5001	Fundamentals of Communications of Skills	0	0	2	0	1
3.	ENG 5002	Professional and Communication Skills	0	0	2	0	1
4.	STS5001	Essentials of Business Etiquettes and Problem Solving	3	-	-	-	1
5.	STS5002	Preparing for Industry	3	-	-	-	1
6.	SET5001	Science, Engineering and Technology Project - I	-	-	-	8	2
7.	SET5002	Science, Engineering and Technology Project - II	-	-	-	8	2
8.	EEE 6099	Master's Thesis	-	-	-	64	16
9.	GER5001/ FRE5001	Deutsch Fuer Anfaenger / Francais Fonctionnel	2	0	0	0	2

Programme Core

S. No.	**Course Code**	**Course Title**	**L**	**T**	**P**	**J**	**C**
1.	EEE5001	Analysis of Power Converters	3	0	2	0	**4**
2.	EEE5002	Generalized Machine Theory	3	0	0	0	**3**
3.	EEE5703	Advanced Processors for Power Converters	3	0	2	0	**4**
4.	EEE5704	Switched Mode Power Supplies	2	0	0	0	**2**
5.	EEE6001	Power Electronics Applications in Power Systems	2	0	0	4	**3**
6.	EEE6010	Industrial Electrical Drives	2	0	2	0	**3**

M. Tech Power Electronics and Drives

Programme Elective

S. No.	Course Code	Course Title	L	T	P	J	C
1.	EEE5005	Advanced Semiconductor Devices	3	0	0	0	3
2.	EEE5006	Integrated Circuits for Power Conversion	2	0	2	0	3
3.	EEE5007	Intelligent Control	3	0	0	0	3
4.	EEE5008	Modern Control Theory	3	0	0	0	3
5.	EEE5009	Energy Storage Systems	3	0	0	0	3
6.	EEE5010	Advanced Power System Protection	3	0	0	0	3
7.	EEE5011	Protocols for Smart Grids	3	0	0	0	3
8.	EEE5031	Advanced Reliability Engineering	1	2	0	0	2
9.	EEE6002	Wind Energy Conversion Systems	2	0	0	4	3
10.	EEE6003	Power Quality Analysis and Mitigation Techniques	2	0	0	4	3
11.	EEE6004	Microgrid Technologies	3	0	0	0	3
12.	EEE6005	Hybrid Electric Vehicles	2	0	0	4	3
13.	EEE6006	High Voltage Direct Current Transmission	3	0	0	4	4
14.	EEE6007	Pulse Width Modulation and Control	2	0	0	4	3
15.	EEE6008	Solar Photo Voltaic Systems	2	0	0	4	3
16.	EEE6009	Special Machines and Control	2	0	0	4	3

MAT5003	Methods of Applied Mathematics	L	T	P	J	C
		3	0	0	0	3
Pre-requisite	**NIL**	**Syllabus version**				
		v.1.0				

Course Objectives

1. Enhancing the basic understanding of the methods of Applied Mathematics to Engineering
2. Imparting computational thinking capability in relation to using appropriate analytical and optimization methodologies for power electronics problems
3. Extrapolating analytical, numerical and optimization skills to real time scenarios, with reference to electronics problems

Expected Course Outcome

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

1. apply the concept of matrices in formulating practical problems
2. differentiate between numerical and analytical approaches
3. design transform techniques and circuit analysis methodologies
4. Apply Markovian process to solve the power spectrum problems and distinguish the utility of queuing models
5. Apply optimization methods to analyse the gradient methods

Module:1	**Matrix Computations**	**5 hours**

Generalized Conjugate Gradient, Krylov Space and Lanczos methods, Iterative methods for symmetric, non-symmetric and generalized eigen value problems, Singular Value Decomposition

Module:2	**Ordinary Differential Equations**	**5 hours**

Simple nonlinear differential equations: Sturm-Liouville problem. Series solution-Orthogonality and related recurrence relations

Module:3	**Calculus of Variations**	**6 hours**

Concept of variation, Euler-Lagrange equations -Rayleigh- Ritz method- Galerkin method

Module:4	**Transforms Techniques**	**10 hours**

The Transfer Function and the Steady state Sinusoidal Response, The Impulse Function in Circuit Analysis Fast Fourier transform, Short time Fourier transform, window measures, time frequency analysis

Module:5	**Stochastic Processes**	**6 hours**

Markovian Processes, Stationary and Non-stationary processes, Time variant and Time invariant signals, Ergodic processes, Covariance, Correlation Auto & cross correlations, Power Spectrum

Module:6	**Queuing Models**	**5 hours**

Poisson Process, Markovian queues, Single and Multi-Server Models , Little’s formula , Machine Interference Model , Steady State analysis

Module:7	**Optimization methods**	**6 hours**

Basic concepts of Optimization, Unconstrained multivariable Optimization- Steepest

Descent and Conjugate Gradient Methods, Constrained Optimization- Lagrange multiplier method				
Module:8	**Contemporary issues:**			**2 hours**
Expert Lecturer: Mathematical methods and its Application to Dynamics and Electromagnetic fields				
	Total Lecture hours:			**45 hours**
Text Book(s)				
1.	Advanced Engineering Mathematics, Erwin Kreyszig, 10^{th} Edition, Wiley India student Edition, (2015)			
Reference Books				
1.	Higher Engineering Mathematics, B.S.Grewal , 43^{rd} Edition, Khanna Publications (2015)			
2.	Probability, Random Variables and Stochastic Processes, A. Papoulis and S.U.Pillai, 4^{th} Edition, Tata McGraw-Hill, (2014) reprint			
3.	Matrix Computations, G. H, Golub and C. F. Van Loan, North Oxford Academics, (1983), 4th edition, Johns Hopkins University press			
4.	Operations Research, H. A. Taha, 10^{th} Edition, Pearson Education (2019)			
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar				
Recommended by Board of Studies		**09/03/2016**		
Approved by Academic Council		**40th**	Date	**18/03/2016**

VIT
Vellore Institute of Technology
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ENG5001	Fundamentals of Communication Skills	L	T	P	J	C
		0	0	2	0	1
Pre-requisite	Not cleared EPT (English Proficiency Test)	Syllabus version				
		v. 1.0				

Course Objectives:

1. To enable learners learn basic communication skills - Listening, Speaking, Reading and Writing
2. To help learners apply effective communication in social and academic context
3. To make students comprehend complex English language through listening and reading

Expected Course Outcome:

1. Enhance the listening and comprehending skills of the learners
2.Acquire speaking skills to express their thoughts freely and fluently
3.Learn strategies for effective reading
4.Write grammatical correct sentences in general and academic writing
5. Develop technical writing skills like writing instructions, transcoding etc.,

Module:1	Listening	8 hours

Understanding Conversation
Listening to Speeches
Listening for Specific Information

Module:2	Speaking	4 hours

Exchanging Information
Describing Activities, Events and Quantity

Module:3	Reading	6 hours

Identifying Information
Inferring Meaning
Interpreting text

Module:4	Writing: Sentence	8hours

Basic Sentence Structure
Connectives
Transformation of Sentences
Synthesis of Sentences

Module:5	Writing: Discourse	4hours

Instructions
Paragraph
Transcoding

Total Lecture hours: 30 hours

Text Book(s)

1.	Redston, Chris, Theresa Clementson, and Gillie Cunningham. Face2face Upper Intermediate Student's Book. 2013, Cambridge University Press.

Reference Books

1	Chris Juzwiak .Stepping Stones: A guided approach to writing sentences and Paragraphs (Second Edition), 2012, Library of Congress.
2.	Clifford A Whitcomb & Leslie E Whitcomb, Effective Interpersonal and Team Communication Skills for Engineers, 2013, John Wiley & Sons, Inc., Hoboken: New Jersey.

3.	ArunPatil, Henk Eijkman &Ena Bhattacharya, New Media Communication Skills for Engineers and IT Professionals,2012, IGI Global, Hershey PA.
4.	Judi Brownell, Listening: Attitudes, Principles and Skills, 2016, 5th Edition, Routledge:USA
5.	John Langan, Ten Steps to Improving College Reading Skills, 2014, 6th Edition, Townsend Press:USA
6.	Redston, Chris, Theresa Clementson, and Gillie Cunningham. Face2face Upper Intermediate Teacher's Book. 2013, Cambridge University Press.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

1.	Familiarizing students to adjectives through brainstorming adjectives with all letters of the English alphabet and asking them to add an adjective that starts with the first letter of their name as a prefix.	2 hours
2.	Making students identify their peer who lack Pace, Clarity and Volume during presentation and respond using Symbols.	4 hours
3.	Using Picture as a tool to enhance learners speaking and writing skills	2 hours
4.	Using Music and Songs as tools to enhance pronunciation in the target language / Activities through VIT Community Radio	2 hours
5.	Making students upload their Self- introduction videos in Vimeo.com	4 hours
6.	Brainstorming idiomatic expressions and making them use those in to their writings and day to day conversation	4 hours
7.	Making students Narrate events by adding more descriptive adjectives and add flavor to their language / Activities through VIT Community Radio	4 hours
8	Identifying the root cause of stage fear in learners and providing remedies to make their presentation better	4 hours
9	Identifying common Spelling & Sentence errors in Letter Writing and other day to day conversations	2 hours
10.	Discussing FAQ's in interviews with answers so that the learner gets a better insight in to interviews / Activities through VIT Community Radio	2 hours
	Total Laboratory Hours	**30 hours**

Mode of evaluation: Online Quizzes, Presentation, Role play, Group Discussions, Assignments, Mini Project

Recommended by Board of Studies	**22-07-2017**		
Approved by Academic Council	**No. 46**	Date	**24-8-2017**

ENG5002	Professional and Communication Skills		L	T	P	J	C
			0	0	2	0	1
Pre-requisite	ENG5001	Syllabus version					
		v. 1.1					

Course Objectives:

1. To enable students to develop effective Language and Communication Skills
2. To enhance students' Personal and Professional skills
3. To equip the students to create an active digital footprint

Expected Course Outcome:

1. Improve inter-personal communication skills
2. Develop problem solving and negotiation skills
3. Learn the styles and mechanics of writing research reports
4. Cultivate better public speaking and presentation skills
5. Apply the acquired skills and excel in a professional environment

Module:1	**Personal Interaction**	**2hours**
Introducing Oneself- one's career goals Activity: SWOT Analysis		
Module:2	**Interpersonal Interaction**	**2 hours**
Interpersonal Communication with the team leader and colleagues at the workplace Activity: Role Plays/Mime/Skit		
Module:3	**Social Interaction**	**2 hours**
Use of Social Media, Social Networking, gender challenges Activity: Creating LinkedIn profile, blogs		
Module:4	**Résumé Writing**	**4 hours**
Identifying job requirement and key skills Activity: Prepare an Electronic Résumé		
Module:5	**Interview Skills**	**4 hours**
Placement/Job Interview, Group Discussions Activity: Mock Interview and mock group discussion		
Module:6	**Report Writing**	**4 hours**
Language and Mechanics of Writing Activity: Writing a Report		
Module:7	**Study Skills: Note making**	**2hours**
Summarizing the report Activity: Abstract, Executive Summary, Synopsis		
Module:8	**Interpreting skills**	**2 hours**
Interpret data in tables and graphs Activity: Transcoding		
Module:9	**Presentation Skills**	**4 hours**
Oral Presentation using Digital Tools Activity: Oral presentation on the given topic using appropriate non-verbal cues		
Module:10	**Problem Solving Skills**	**4 hours**

Problem Solving & Conflict Resolution Activity: Case Analysis of a Challenging Scenario			
		Total Lecture hours:	**30hours**
Text Book(s)			
1	Bhatnagar Nitin and Mamta Bhatnagar, Communicative English For Engineers And Professionals, 2010, Dorling Kindersley (India) Pvt. Ltd.		
Reference Books			
1	Jon Kirkman and Christopher Turk, Effective Writing: Improving Scientific, Technical and Business Communication, 2015, Routledge		
2	Diana Bairaktarova and Michele Eodice, Creative Ways of Knowing in Engineering, 2017, Springer International Publishing		
3	Clifford A Whitcomb & Leslie E Whitcomb, Effective Interpersonal and Team Communication Skills for Engineers, 2013, John Wiley & Sons, Inc., Hoboken: New Jersey.		
4	ArunPatil, Henk Eijkman &Ena Bhattacharya, New Media Communication Skills for Engineers and IT Professionals,2012, IGI Global, Hershey PA.		
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			

1.	SWOT Analysis – Focus specially on describing two strengths and two weaknesses	2 hours
2.	Role Plays/Mime/Skit -- Workplace Situations	4 hours
3.	Use of Social Media – Create a LinkedIn Profile and also write a page or two on areas of interest	2 hours
4.	Prepare an Electronic Résumé and upload the same in vimeo	2 hours
5.	Group discussion on latest topics	4 hours
6	Report Writing – Real-time reports	2 hours
7	Writing an Abstract, Executive Summary on short scientific or research articles	4 hours
8	Transcoding – Interpret the given graph, chart or diagram	2 hours
9	Oral presentation on the given topic using appropriate non-verbal cues	4 hours
10	Problem Solving -- Case Analysis of a Challenging Scenario	4 hours
	Total Laboratory Hours	**30 hours**
Mode of evaluation: : Online Quizzes, Presentation, Role play, Group Discussions, Assignments, Mini Project		

Recommended by Board of Studies	**22-07-2017**		
Approved by Academic Council	**No. 47**	Date	**05-10-2017**

STS5001	Essentials of Business Etiquettes and Problem Solving	L	T	P	J	C
		3	0	0	0	1
Pre-requisite	NIL	**Syllabus version**				
		v.3.0				

Course Objectives:

1. To develop the students' logical thinking skills
2. To learn the strategies of solving quantitative ability problems
3. To enrich the verbal ability of the students
4. To enhance critical thinking and innovative skills

Expected Course Outcome:

1. Enabling students to use relevant aptitude and appropriate language to express themselves
2. To communicate the message to the target audience clearly

Module:1	**Business Etiquette: Social and Cultural Etiquette and Writing Company Blogs and Internal Communications and Planning and Writing press release and meeting notes**	**9 hours**

Value, Manners, Customs, Language, Tradition, Building a blog, Developing brand message, FAQs', Assessing Competition, Open and objective Communication, Two way dialogue, Understanding the audience, Identifying, Gathering Information,. Analysis, Determining, Selecting plan, Progress check, Types of planning, Write a short, catchy headline, Get to the Point –summarize your subject in the first paragraph., Body – Make it relevant to your audience,

Module:2	**Study skills – Time management skills**	**3 hours**

Prioritization, Procrastination, Scheduling, Multitasking, Monitoring, Working under pressure and adhering to deadlines

Module:3	**Presentation skills – Preparing presentation and Organizing materials and Maintaining and preparing visual aids and Dealing with questions**	**7 hours**

10 Tips to prepare PowerPoint presentation, Outlining the content, Passing the Elevator Test, Blue sky thinking, Introduction , body and conclusion, Use of Font, Use of Color, Strategic presentation, Importance and types of visual aids, Animation to captivate your audience, Design of posters, Setting out the ground rules, Dealing with interruptions, Staying in control of the questions, Handling difficult questions

Module:4	**Quantitative Ability -L1 – Number properties and Averages and Progressions and Percentages and Ratios**	**11 hours**

Number of factors, Factorials, Remainder Theorem, Unit digit position, Tens digit position, Averages, Weighted Average, Arithmetic Progression, Geometric Progression, Harmonic Progression, Increase & Decrease or successive increase, Types of ratios and proportions

Module:5	**Reasoning Ability-L1 – Analytical Reasoning**	**8 hours**

Data Arrangement(Linear and circular & Cross Variable Relationship), Blood Relations,

Ordering/ranking/grouping, Puzzle test, Selection Decision table		
Module:6	**Verbal Ability-L1 – Vocabulary Building**	**7 hours**
Synonyms & Antonyms, One word substitutes, Word Pairs, Spellings, Idioms, Sentence completion, Analogies		
	Total Lecture hours:	**45 hours**

Reference Books

1.	Kerry Patterson, Joseph Grenny, Ron McMillan, Al Switzler(2001) Crucial Conversations: Tools for Talking When Stakes are High. Bangalore. McGraw-Hill Contemporary
2.	Dale Carnegie,(1936) How to Win Friends and Influence People. New York. Gallery Books
3.	Scott Peck. M(1978) Road Less Travelled. New York City. M. Scott Peck.
4.	FACE(2016) Aptipedia Aptitude Encyclopedia. Delhi. Wiley publications
5.	ETHNUS(2013) Aptimithra. Bangalore. McGraw-Hill Education Pvt. Ltd.

Websites:

1.	www.chalkstreet.com
2.	www.skillsyouneed.com
3.	www.mindtools.com
4.	www.thebalance.com
5.	www.eguru.ooo

Mode of Evaluation: FAT, Assignments, Projects, Case studies, Role plays,
3 Assessments with Term End FAT (Computer Based Test)

Recommended by Board of Studies			
Approved by Academic Council	**53rd**	Date	**13/12/2018**

STS5002	Preparing for Industry	L	T	P	J	C
		3	0	0	0	1
Pre-requisite	NIL	**Syllabus version**				
		v.2.0				

Course Objectives:

1. To develop the students' logical thinking skills
2. To learn the strategies of solving quantitative ability problems
3. To enrich the verbal ability of the students
4. To enhance critical thinking and innovative skills

Expected Course Outcome:

1. Enabling students to simplify, evaluate, analyze and use functions and expressions to simulate real situations to be industry ready.

Module:1	**Interview skills – Types of interview and Techniques to face remote interviews and Mock Interview**	**3 hours**

Structured and unstructured interview orientation, Closed questions and hypothetical questions, Interviewers' perspective, Questions to ask/not ask during an interview, Video interview¸ Recorded feedback, Phone interview preparation, Tips to customize preparation for personal interview, Practice rounds

Module:2	**Resume skills – Resume Template and Use of power verbs and Types of resume and Customizing resume**	**2 hours**

Structure of a standard resume, Content, color, font, Introduction to Power verbs and Write up, Quiz on types of resume, Frequent mistakes in customizing resume, Layout - Understanding different company's requirement, Digitizing career portfolio

Module:3	**Emotional Intelligence - L1 – Transactional Analysis and Brain storming and Psychometric Analysis and Rebus Puzzles/Problem Solving**	**12 hours**

Introduction, Contracting, ego states, Life positions, Individual Brainstorming, Group Brainstorming, Stepladder Technique, Brain writing, Crawford's Slip writing approach, Reverse brainstorming, Star bursting, Charlette procedure, Round robin brainstorming, Skill Test, Personality Test, More than one answer, Unique ways

Module:4	**Quantitative Ability-L3 – Permutation-Combinations and Probability and Geometry and mensuration and Trigonometry and Logarithms and Functions and Quadratic Equations and Set Theory**	**14 hours**

Counting, Grouping, Linear Arrangement, Circular Arrangements, Conditional Probability, Independent and Dependent Events, Properties of Polygon, 2D & 3D Figures, Area & Volumes, Heights and distances, Simple trigonometric functions, Introduction to logarithms, Basic rules of logarithms, Introduction to functions, Basic rules of functions, Understanding Quadratic Equations, Rules & probabilities of Quadratic Equations, Basic concepts of Venn Diagram

Module:5	**Reasoning ability-L3 – Logical reasoning and Data Analysis and Interpretation**	**7 hours**

Syllogisms, Binary logic, Sequential output tracing, Crypto arithmetic, Data Sufficiency, Data interpretation-Advanced, Interpretation tables, pie charts & bar chats		
Module:6	**Verbal Ability-L3 – Comprehension and Logic**	**7 hours**
Reading comprehension, Para Jumbles, Critical Reasoning (a) Premise and Conclusion, (b) Assumption & Inference, (c) Strengthening & Weakening an Argument		
	Total Lecture hours:	**45 hours**

Reference Books

1.	Michael Farra and JIST Editors(2011) Quick Resume & Cover Letter Book: Write and Use an Effective Resume in Just One Day. Saint Paul, Minnesota. Jist Works
2.	Daniel Flage Ph.D(2003) The Art of Questioning: An Introduction to Critical Thinking. London. Pearson
3.	David Allen(2002) Getting Things done : The Art of Stress -Free productivity. New York City. Penguin Books.
4.	FACE(2016) Aptipedia Aptitude Encyclopedia.Delhi. Wiley publications
5.	ETHNUS(2013) Aptimithra. Bangalore. McGraw-Hill Education Pvt. Ltd.

Websites:

1.	www.chalkstreet.com
2.	www.skillsyouneed.com
3.	www.mindtools.com
4.	www.thebalance.com
5.	www.eguru.ooo

Mode of Evaluation: FAT, Assignments, Projects, Case studies, Role plays,
3 Assessments with Term End FAT (Computer Based Test)

Recommended by Board of Studies	**09/06/2017**		
Approved by Academic Council	**45th AC**	Date	**15/06/2017**

Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

EEE6099	Masters Thesis	L	T	P	J	C
		0	0	0	0	16
Pre-requisite	**As per the academic regulations**	**Syllabus version**				
		v. 1.0				

Course Objectives:

To provide sufficient hands-on learning experience related to the design, development and analysis of suitable product / process so as to enhance the technical skill sets in the chosen field and also to give research orientation

Expected Course Outcome:

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

1. Formulate specific problem statements for ill-defined real life problems with reasonable assumptions and constraints.
2. Perform literature search and / or patent search in the area of interest.
3. Conduct experiments / Design and Analysis / solution iterations and document the results.
4. Perform error analysis / benchmarking / costing
5. Synthesise the results and arrive at scientific conclusions / products / solution
6. Document the results in the form of technical report / presentation

Contents

1. Capstone Project may be a theoretical analysis, modeling & simulation, experimentation & analysis, prototype design, fabrication of new equipment, correlation and analysis of data, software development, applied research and any other related activities.
2. Project can be for two semesters based on the completion of required number of credits as per the academic regulations.
3. Should be individual work.
4. Carried out inside or outside the university, in any relevant industry or research institution.
5. Publications in the peer reviewed journals / International Conferences will be an added advantage

Mode of Evaluation**:** Periodic reviews, Presentation, Final oral viva, Poster submission

Recommended by Board of Studies	**10.06.2016**		
Approved by Academic Council	**41st AC**	Date	**17.06.2016**

GER5001	Deutsch Fuer Anfaenger	L	T	P	J	C
		2	0	0	0	2
Pre-requisite	**NIL**	**Syllabus version**				
		v.1.0				

Course Objectives:

The course gives students the necessary background to:

1. Enable students to read and communicate in German in their day to day life
2. Become industry-ready
3. Make them understand the usage of grammar in the German Language.

Expected Course Outcome:

The students will be able to

1. Create the basics of German language in their day to day life.
2. Understand the conjugation of different forms of regular/irregular verbs.
3. Understand the rule to identify the gender of the Nouns and apply articles appropriately.
4. Apply the German language skill in writing corresponding letters, E-Mails etc.
5. Create the talent of translating passages from English-German and vice versa and To frame simple dialogues based on given situations.

Module:1		**3 hours**

Einleitung, Begrüssungsformen, Landeskunde, Alphabet, Personalpronomen, Verb Konjugation, Zahlen (1-100), W-fragen, Aussagesätze, Nomen – Singular und Plural

Lernziel: Elementares Verständnis von Deutsch, Genus- Artikelwörter

Module:2		**3 hours**

Konjugation der Verben (regelmässig /unregelmässig) die Monate, die Wochentage, Hobbys, Berufe, Jahreszeiten, Artikel, Zahlen (Hundert bis eine Million), Ja-/Nein- Frage, Imperativ mit Sie

Lernziel : Sätze schreiben, über Hobbys erzählen, über Berufe sprechen usw.

Module:3		**4 hours**

Possessivpronomen, Negation, Kasus- AkkusatitvundDativ (bestimmter, unbestimmterArtikel), trennnbare verben, Modalverben, Adjektive, Uhrzeit, Präpositionen, Mahlzeiten, Lebensmittel, Getränke

Lernziel : Sätze mit Modalverben, Verwendung von Artikel, über Länder und Sprachen sprechen, über eine Wohnung beschreiben.

Module:4		**6 hours**

Übersetzungen : (Deutsch – Englisch / Englisch – Deutsch)

Lernziel : Grammatik – Wortschatz – Übung

Module:5		**5 hours**

Leseverständnis,Mindmap machen,Korrespondenz- Briefe, Postkarten, E-Mail

Lernziel : Wortschatzbildung und aktiver Sprach gebrauch

Module:6	.	**3 hours**

Aufsätze :

Meine Universität, Das Essen, mein Freund oder meine Freundin, meine Familie, ein Fest in Deutschland usw			
Module:7			**4 hours**
Dialoge: a) Gespräche mit Familienmitgliedern, Am Bahnhof, b) Gespräche beim Einkaufen ; in einem Supermarkt ; in einer Buchhandlung ; c) in einem Hotel - an der Rezeption ;ein Termin beim Arzt. Treffen im Cafe			
Module:8			**2 hours**
Guest Lectures/Native Speakers / Feinheiten der deutschen Sprache, Basisinformation über die deutschsprachigen Länder			
	Total Lecture hours:	**30 hours**	

Text Book(s)	
1.	**Studio d A1 Deutsch als Fremdsprache, Hermann Funk, Christina Kuhn, Silke Demme : 2012**
Reference Books	
1	Netzwerk Deutsch als Fremdsprache A1, Stefanie Dengler, Paul Rusch, Helen Schmtiz, Tanja Sieber, 2013
2	Lagune ,Hartmut Aufderstrasse, Jutta Müller, Thomas Storz, 2012.
3	Deutsche SprachlehrefürAUsländer, Heinz Griesbach, Dora Schulz, 2011
4	ThemenAktuell 1, HartmurtAufderstrasse, Heiko Bock, MechthildGerdes, Jutta Müller und Helmut Müller, 2010
	www.goethe.de wirtschaftsdeutsch.de hueber.de, klett-sprachen.de www.deutschtraning.org

Mode of Evaluation: CAT / Assignment / Quiz / FAT			
Recommended by Board of Studies	**10/06/2016**		
Approved by Academic Council	**41th**	Date	**17/06/2016**

FRE5001	Francais Fonctionnel	L	T	P	J	C
		2	0	0	0	2
Pre-requisite	**NIL**	**Syllabus version**				
		v.1.0				

Course Objectives:

The course gives students the necessary background to:

1. Demonstrate competence in reading, writing, and speaking basic French, including knowledge of vocabulary (related to profession, emotions, food, workplace, sports/hobbies, classroom and family).
2. Achieve proficiency in French culture oriented view point.

Expected Course Outcome:

The students will be able to

1. Remember the daily life communicative situations via personal pronouns, emphatic pronouns, salutations, negations, interrogations etc.
2. Create communicative skill effectively in French language via regular / irregular verbs.
3. Demonstrate comprehension of the spoken / written language in translating simple sentences.
4. Understand and demonstrate the comprehension of some particular new range of unseen written materials.
5. Demonstrate a clear understanding of the French culture through the language studied.

Module:1	Saluer, Se présenter, Etablir des contacts	**3 hours**

Les Salutations, Les nombres (1-100), Les jours de la semaine, Les mois de l'année, Les Pronoms Sujets, Les Pronoms Toniques, La conjugaison des verbes réguliers, La conjugaison des verbes irréguliers- avoir / être / aller / venir / faire etc.

Module:2	**Présenter quelqu'un, Chercher un(e) correspondant(e), Demander des nouvelles d'une personne.**	**3 hours**

La conjugaison des verbes Pronominaux, La Négation,
L'interrogation avec 'Est-ce que ou sans Est-ce que'.

Module:3	**Situer un objet ou un lieu, Poser des questions**	**4 hours**

L'article (défini/ indéfini), Les prépositions (à/en/au/aux/sur/dans/avec etc.), L'article contracté, Les heures en français, La Nationalité du Pays, L'adjectif (La Couleur, l'adjectif possessif, l'adjectif démonstratif/ l'adjectif interrogatif (quel/quelles/quelle/quelles), L'accord des adjectifs avec le nom, L'interrogation avec Comment/ Combien / Où etc.,

Module:4	**Faire des achats, Comprendre un texte court, Demander et indiquer le chemin.**	**6 hours**

La traduction simple :(français-anglais / anglais –français)

Module:5	**Trouver les questions, Répondre aux**	**5 hours**

	questions générales en français.	
L'article Partitif, Mettez les phrases aux pluriels, Faites une phrase avec les mots donnés, Exprimez les phrases données au Masculin ou Féminin, Associez les phrases.		
Module:6	**Comment ecrire un passage**	**3 hours**
Décrivez : La Famille /La Maison, /L'université /Les Loisirs/ La Vie quotidienne etc.		
Module:7	**Comment ecrire un dialogue**	**4 hours**
Dialogue: a) Réserver un billet de train b) Entre deux amis qui se rencontrent au café c) Parmi les membres de la famille d) Entre le client et le médecin		
Module:8	**Invited Talk: Native speakers**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	Echo-1, Méthode de français, J. Girardet, J. Pécheur, Publisher CLE International, Paris 2010.
2	Echo-1, Cahier d'exercices, J. Girardet, J. Pécheur, Publisher CLE International, Paris 2010.
Reference Books	
1.	CONNEXIONS 1, Méthode de français, Régine Mérieux, Yves Loiseau,Les Éditions Didier, 2004.
2	CONNEXIONS 1, Le cahier d'exercices, Régine Mérieux, Yves Loiseau, Les Éditions Didier, 2004.
3	ALTER EGO 1, Méthode de français, Annie Berthet, Catherine Hugo, Véronique M. Kizirian, Béatrix Sampsonis, Monique Waendendries , Hachette livre 2006.

Mode of Evaluation: CAT / Assignment / Quiz / FAT			
Recommended by Board of Studies	**10/06/2016**		
Approved by Academic Council	**41th**	Date	**17/06/2016**

EEE5001	Analysis of Power Converters	L	T	P	J	C
		3	0	2	0	4
Pre-requisite	**NIL**	**Syllabus version**				
Anti-requisite	NIL	v. 1.0				

Course Objectives:

1. To understand and appreciate the operating principle and applications of various power electronic converters.

Expected Course Outcome:

On the completion of this course the student will be able to:

1. Analyze switching power converters in steady state and determine DC voltages and currents.
2. Analyze current and voltage waveforms in a converter in steady state
3. Explain the operation of different DC-DC converters and design converters suitable for various applications.
4. Assess the performance parameters of various types of inverters, analyze and compare different PWM techniques for their control
5. Explain the application of cycloconverter and AC voltage regulators
6. Discuss the principle of operation and model and simulate the advanced converters such as of Multi-level converters , PWM rectifiers & Matrix converter
7. Understand the controlling aspects involved.
8. Design and Conduct experiments, as well as analyze and interpret data

Module:1	SINGLE PHASE UNCONTROLLED AND CONTROLLED RECTIFIERS:	7 hours

Single Phase AC to DC Controlled converter configurations – Semi-converter – Fully controlled converter – R, RL, RLE load – operation under continuous and discontinuous conduction – Analysis of supply side power factor – effect of source impedance – Dual converter

Module:2	THREE PHASE UNCONTROLLED AND CONTROLLED RECTIFIERS:	7 hours

Three Phase AC to DC converters configurations – Un-controlled - Semi-converter – Fully controlled converter – Analysis of supply side power factor – three phase dual converter.

Module:3	DC-DC CONVERTERS:	7 hours

Analysis and design of DC to DC converters – Control of DC-DC converter – Buck, Boost, Buck-Boost and Cuk converters – multi-quadrant choppers.

Module:4	DC-AC INVERTERS:	6 hours

Single phase Voltage Source Inverter (VSI) and Current Source Inverter (CSI) – three phase VSI and CSI - 120° and 180° modes of operation.

Module:5	AC VOLTAGE CONTROLLERS:	5 hours

Single phase and three phase voltage regulators – R and RL load – range of control – Single phase cycloconverters – types and operating principle – three phase cycloconverter.

Module:6	ADVANCED POWER CONVERTERS:	6 hours

PWM Rectifier – multilevel inverters – types, power circuit, operating principle and

comparative features – Matrix converter.		
Module:7	**CONTROL TECHNIQUES:**	**5 hours**
Concept of PWM – Sine PWM – harmonic spectrum – Space vector PWM – voltage control and harmonic reduction.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar		

1.	Single phase one quadrant AC-DC rectifier	hours
2.	Single phase two quadrant AC-DC rectifier	2 hours
3.	Two quadrant high power AC-DC rectifier	2 hours
4.	Step-up chopper with R, RL loads	2 hours
5.	Converter for battery charging in PV systems	2 hours
6.	Buck-Boost converter	2 hours
7.	Interleaved boost converter	2 hours
8.	Interleaved buck converter	2 hours
9.	Home UPS	2 hours
10.	Three phase inverter operating under 120 °and 180 ° modes	2 hours
11.	Fan regulators and light dimmers	2 hours
12.	Three phase AC-AC voltage regulator with R, RL loads	2 hours
13.	Single phase Step up cycloconverter	2 hours
14.	Single phase Step down cycloconverter	2 hours
15.	Diode clamped multilevel inverter	2 hours
16.	Flying capacitor multilevel inverter	2 hours
17.	Cascade type multilevel inverter	2 hours
18.	Closed loop control of boost converter	2 hours
19.	Closed loop control of buck converter	2 hours
20.	Power factor correction using buck-boost converter	2 hours
	Total Laboratory Hours	**30 hours**
Text Book(s)		
1.	Rashid M.H., "Power Electronics-Circuits, Devices and Applications", Prentice HallIndia, New Delhi, 2013.	
2.	William Shepherd and Li Zhang, "Power Converter Circuits", Marcel Dekker Inc, New York, 2004.	
Reference Books		
1.	Joseph Vithayathil, "Power Electronics – Principles and Applications", Tata McGraw-Hill edition, 2010.	
2.	Bin Wu, Mehdi Narimani, "High-Power Converters and AC Drives", John Wiley & Sons, 2017.	

Recommended by Board of Studies	**05/03/2016**		
Approved by Academic Council	**40th AC**	Date	**18/03/2016**

EEE5002	Generalized Machine Theory		L	T	P	J	C
			3	0	0	0	3
Pre-requisite	**NIL**	**Syllabus version**					
Anti-requisite	**NIL**	v. 1.0					

Course Objectives:

1. To provide knowledge about the fundamentals of magnetic circuits, energy, force and torque of multi-excited systems.
2. To introduce the concepts of mathematical modelling of electrical machines.
3. To provide the knowledge of theory of transformation of three phase variables to two phase variables.
4. To analyze the steady state and dynamic state operation of induction machine and synchronous through mathematical modeling.

Expected Course Outcome:

1. Interpret the machine in steady state
2. Interpret the machine dynamics
3. Analyze the electrical machine equivalent circuit parameters and modeling of electrical machines.
4. Develop the mathematical model of electro mechanical energy conversion system
5. Develop the mathematical model of special machine
6. Explain the various electrical parameters in mathematical form.
7. Summarize the different types of reference frame theories and transformation relationships.

Module:1	Energy in Magnetic System:	5 hours
Single and multiple excited systems - Field energy - co-energy and mechanical force - electromechanical energy conversion - single and multiple excited systems - torque and force expression		
Module:2	**Linear Transformation:**	**5 hours**
Kron's theory - transformation from three phase to two phase - transformation from rotating axes to stationary axes-Park's Transformation - Physical Interpretation.		
Module:3	**Reference Frame Theory**:	**5 hours**
Reference frame theory - transformation between reference frames - stationary circuit variable transformation - steady state voltage equation.		
Module:4	**3-phase induction motor**:	**9 hours**
Voltage and torque equation: machine variables - arbitrary reference frame and rotor reference frames - steady state operation - dynamic model - operations of induction motor with non- sinusoidal supply waveforms - simulation of arbitrary reference frame and linearised model.		
Module:5	**2- Phase Induction motor:**	**5 hours**
Voltage and torque equation: machine variables - arbitrary reference frame and rotor reference frames- steady state operation - dynamic model - operations of induction motor with non- sinusoidal supply waveforms - simulation of arbitrary reference frame and linearised model		
Module:6	**Synchronous Machine**:	**8 hours**
Reactance of synchronous machine - time constants of synchronous machine - voltage and torque		

equation: Machine variables - arbitrary reference frame and rotor reference frames park's equation - dynamic model of synchronous machine - effects of magnetic saturation simulation of linearised model.				
Module:7	**Special Machine Modeling:**		**6 hours**	
Steady-state and dynamic model: Permanent magnet synchronous machine - BLDC motor-Steady-state and dynamic model of switched reluctance motor.				
Module:8	**Contemporary issues:**		**2 hours**	
	Total Lecture hours:	**45 hours**		
Text Book(s)				
1.	Fitzgerald A. E., Kingsley and Umans, "Electric Machinery", McGraw-Hill Book Company, 7th edition, 2013.			
2.	P.C.Krause, Oleg Wasynczuk and Scoot D. Sudhoff, "Analysis of Electrical Machinery and Drives System", IEEE Press, 2013.			
Reference Books				
1.	P. S. Bimbhra, "Generalized Theory of Electrical Machines", Khanna Publishers, 2013.			
Recommended by Board of Studies	**05/03/2016**			
Approved by Academic Council	**40th AC**	Date	**18/03/2016**	

EEE5703	Advanced Processors for Power Converters	L	T	P	J	C
		3	0	2	0	4
Pre-requisite	NIL	Syllabus version				
Anti-requisite	NIL	v. 1.0				

Course Objectives:

1. Introducing ARM Processor and DSP controller
2. Overview of resources available in ARM Processor and DSP-controller
3. Overview of programming frame work, software building blocks and Interrupt structures, Event manager, and compare unit
4. To design control circuits for power converters

Expected Course Outcome:

On the completion of this course the student will be able to:

1. Describe the architecture of ARM processor
2. Use the Timers and PWM to generate triggering pulses for power electronic circuits
3. Experiment with the exceptions of ARM processor to vary the triggering pulses for power electronic circuits
4. Apply digital signal processing in ARM processor
5. Explain the architecture of DSP processor
6. Experiment with the peripherals of DSP processor for power electronics applications
7. Experiment with the DSP processor for real time power electronic problems
8. Design and Conduct experiments, as well as analyze and interpret data

Module:1	ARM Processors:	4 hours

Arm processor architecture and pipelining –programmer's model –data paths and instruction decoding –ARM instruction set –addressing modes – General Purpose Input and Output (GPIO) - Analog to Digital Converter – Digital to Analog Converter – Simple programming

Module:2	Timers and PWM:	6 hours

Different modes of operation of Timers - Match Registers – Generation of PWM using Compare registers - Capture Control – Single and Double Edge Controlled PWM – programming

Module:3	Exception and Interrupt Handling:	6 hours

Exception handling overview – Interrupts – Interrupt Handling Schemes – Utility of interrupts in closed loop control of a real time system - programming - Advanced Microcontroller Bus architecture.

Module:4	Digital Signal Processing with ARM:	6 hours

Representing a Digital Signal – Introduction to DSP on the ARM – Industry needs from the digital implementation perspective on the processors.

Module:5	Digital Signal Processor:	6 hours

Basic architecture - System configuration registers – Memory addressing mode – Interrupt handling – Instruction set – Programming Concepts – Simple programs.

Module:6	Peripherals of DSP :	8 hours

General purpose Input/Output (GPIO) Functionality- Utilization of GPIO in PWM signal generation - Interrupts - A/D converter – Event Managers (EVA, EVB) - PWM signal generation for single phase inverter.			
Module:7	**Case Studies using ARM and DSP:**		**7 hours**
Control of DC-DC converters- Inverters control (PWM, Space vector PWM) –ac to dc converters – cycloconverters – Closed loop control concepts			
Module:8	**Lecture by industry experts.**		**2 hours**
	Total Lecture hours:	**45 hours**	
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			

1.	Control signal for obtaining variable duty cycle.	2 hours
2.	Obtaining pulse width modulated signal from a saw tooth and DC signal.	2 hours
3.	Processor based control of a single phase half-wave controlled converter	2 hours
4.	Single phase single quadrant DC-DC converter and its control.	2 hours
5.	Control of a single phase single quadrant bridge type AC-DC converter.	2 hours
6.	Single phase two quadrant AC-DC converter controlled through ARM processor.	2 hours
7.	High power single quadrant bridge type AC-DC converter and its control	2 hours
8.	Control of a High power two quadrant bridge type AC-DC converter.	2 hours
9.	ARM processor based control of a residential UPS.	2 hours
10.	Digital control of high power industrial inverter.	2 hours
11.	Control of three phase AC voltage controller	2 hours
12.	Single phase step down cycloconverter and its control.	2 hours
13.	PWM control of single quadrant DC chopper	2 hours
14.	DSP based implementation of PWM techniques to control an inverter.	2 hours
15.	Control of single phase half controlled converter using DSP processor	2 hours
16.	Control of chopper circuit in TRC and variable frequency method	2 hours
	Total Laboratory Hours	**30 hours**

Text Book(s)	
1.	Andrew N.Sloss, Dominic Symes, Chris Wright, “ARM System Developer’s Guide Designing and Optimizing System Software” Morgan Kaufmann Publishers, 2011.
2.	Hamid A. Toliyat, Steven Campbell, ”DSP based electromechanical motion control”, CRC press, New York, Washington Dc, 2012.
Reference Books	
1.	J.R. Gibson “ARM Assembly Language – an Introduction” Second Edition, lulu.com publishers 2011.

Recommended by Board of Studies	**05/03/2016**		
Approved by Academic Council	**40th AC**	Date	**18/03/2016**

EEE5704	**Switched Mode Power Supplies**	**L**	**T**	**P**	**J**	**C**
		2	**0**	**0**	**0**	**2**
Pre-requisite	**NIL**	**Syllabus version**				
Anti-requisite	**NIL**	v. 1.0				

Course Objectives:

1. To acquire knowledge on switch mode power conversion concepts
2. Design and Development of appropriate switched mode power supplies for particular application

Expected Course Outcome:

On the completion of this course the student will be able to:

1. Analyse different non isolated DC-DC converters for steady-state operation.
2. Develop circuit models for different dc –dc converters
3. Compare isolated and non-isolated dc-dc converters
4. Design magnetic components of dc-dc converters
5. Build dynamic and small signal model of switched mode power converters.
6. Apply soft-switching techniques to DC-DC converter to reduce switching power loss.
7. Select suitable switched mode power converters for particular application

Module:1	**Steady state converter analysis**	**5 hours**
Buck, Boost Buck – Boost and Cuk Converters (CCM &DCM)		
Module:2	**Equivalent circuit modelling, losses, and efficiency**	**5 hours**
Buck, Boost and Buck – Boost Converters		
Module:3	**Isolated converters**	**4 hours**
Significance of an isolated converters – Forward Converter - Fly-back Converter - Half and full bridge Converter		
Module:4	**Magnetic circuit Design**	**4 hours**
Selection of inductor - Design of high frequency Inductor and transformer		
Module:5	**Dynamic Analysis and Control of Switching Converters**	**5 hours**
AC equivalent circuit modelling of converters- dynamic equation of buck & boost converters -Small - signal model & converter transfer functions -Control of converters- voltage & current mode control		
Module:6	**Resonant Converters**	**3 hours**
Classification - Series resonant circuit-parallel resonant circuits - Resonant switches - Zero voltage switching and Zero current switching		
Module:7	**Applications**	**2 hours**
Power Factor Correction in Switching Power Supplies – Low Input SMPS for Laptop Computers and Portable Electronic devices		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)

1.	Robert W. Erickson and Dragan Maksimovic, “Fundamentals of Power Electronics”, Springer, reprint of the original 2nd edition , 2012.
2.	Simon Ang, Alejandro Oliva, “Power-Switching Converters", CRC Press, Vol. No., 3rd Edition, 2010.
Reference Books	
1.	Philip T Krein, “Elements of Power Electronics ", Oxford University Press, 2nd Edition, 2012.
2.	Ned Mohan, Undeland and Robbin, “Power Electronics: converters, Application and design” John Wiley & sons, reprint , 2013.

Mode of Evaluation:	CAT I & II – 30%, DA – 10%, Quiz-I & II – 20%, FAT – 40%

Recommended by Board of Studies	**16-08-2017**		
Approved by Academic Council	**47th AC**	Date	**05/10/2017**

EEE6001	**Power Electronics Applications in Power Systems**	**L**	**T**	**P**	**J**	**C**
		2	**0**	**0**	**4**	**3**
Pre-requisite	**EEE5001**	**Syllabus version**				
Anti-requisite	**NIL**	v. 1.0				
Course Objectives:						
1. To impart in-depth knowledge of reactive power control, system compensation, application of FACTS controllers and power electronics applications in HVDC transmission. 2. To bring out the importance of flexible AC transmission systems and controllers. 3. To explain the concept of stability and their effects						
Expected Course Outcome:						
On the completion of this course the student will be able to: 1. Apply the concept of load compensation and reactive power control to AC power system 2. Summarize the operation of Shunt connected FACTS devices 3. Differentiate between the series and shunt connected FACTS controllers 4. Modeling and simulation various FACTS controllers for power transmission 5. Illustrate the effect of the presence of multiple FACTS controllers in a network 6. Describe the application of FACTS controllers to damp oscillation 7. Apply various control techniques to HVDC transmission 8. Design a component or a product applying all the relevant standards with realistic constraints						
Module:1	**Reactive Power Control:**	**4 hours**				
Steady state and dynamic problems in AC systems- Theory of Load compensation- Principles of shunt and series compensation - Power factor correction- Voltage regulation and Phase balancing.						
Module:2	**Shunt devices**:	**5 hours**				
Introduction to Flexible AC transmission systems (FACTS), Thyristor switched capacitors (TSC) , Thyristor Controlled Reactors (TCR) - Static Var Compensators (SVC) - Static Synchronous compensator (STATCOM).						
Module:3	**Series Devices:**	**3 hours**				
Thyristor Controlled series compensators (TCSC), Static synchronous series compensator (SSSC).						
Module:4	**Modelling and Analysis of FACTS devices:**	**5 hours**				
Mathematical Modelling of FACTS devices (SVC, SSSC, TCSC, STATCOM and Unified power flow controller (UPFC)) - Case Studies.						
Module:5	**Co-ordination of FACTS Controllers:**	**4 hours**				
Control strategies to improve system stability - Co-ordination of FACTS controllers						
Module:6	**Application of FACTS devices:**	**3 hours**				
Subsynchronous resonance, Damping oscillations, Transient stability and voltage stability						
Module:7	**HVDC Transmission**:	**4 hours**				
Introduction to HVDC Transmission, Comparison AC and DC Transmission systems, HVDC						

configurations - components of HVDC system -HVDC system Control, modern HVDC systems, HVDC Installations in India.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar		
	List of Projects	
1. Effect of Reactive power compensation in transmission lines		
2. Power factor improvement with capacitors		
3. Voltage regulation using compensation		
4. Load balancing in power system network using compensators		
5. Application of SVC for voltage profile improvement		
6. Application of STATCOM for voltage profile improvement		
7. Simulation of TCSC		
8. Application of UPFC in power system networks		
9. Simulation of STATCOM with mathematical models		
10. Simulation of UPFC with mathematical models		
11. Case studies with FACTS devices		
12. Load flow incorporating SVC		
13. Load flow incorporating STATCOM		
14. Simulation of HVDC systems		
15. Application of FACTS devices in power flow improvement		

Text Book(s)	
1.	Narain Hingorani &Lazzlo Gyugi "Understanding FACTS. Concepts & Technology of FACTS", Standard publishers & distributors, 2001.
2.	Mohan Mathur, Rajiv.K.Varma, "Thyristor Based FACTS Controllers for Electrical Transmission systems" John Wiley and Sons, 2011.
Reference Books	
1.	T.J.E Miller "Reactive Power Control in Electric system" John Wiley & Sons, NY, 2010.
2.	Enrique Acha, Claudio R. Fuerte-Esquivel, Hugo Ambriz-Pérez, "FACTS: Modelling and Simulation in Power Networks", John Wiley, 2011.
3.	K.R.Padiyar, "HVDC Power Transmission Systems", New Academic Science, 2011.

Recommended by Board of Studies	**05/03/2016**		
Approved by Academic Council	**40th AC**	Date	**18/03/2016**

EEE6010	**Industrial Electrical Drives**		**L**	**T**	**P**	**J**	**C**
			2	**0**	**2**	**0**	**3**
Pre-requisite	**EEE 5001,EEE 5002**	**Syllabus version**					
Anti-requisite	**NIL**	v. 1.0					

Course Objectives:

1. To introduce basic concepts of load and drive interaction, speed control concepts of ac and dc drives, speed reversal, regenerative braking aspects, design methodology

Expected Course Outcome:

On the completion of this course the student will be able to:
1. Describe the fundamental concepts of electric drives.
2. Identify the suitable power converters and fix its rating based on requirement.
3. Classify the different types of DC drives and construct its controller.
4. Categorise the AC drives and differentiate from DC drives.
5. Compare scalar and vector control of AC drives
6. Summarise standards for EMI and EMC.
7. Recommend an option for energy savings in electric drives.
8. Design and Conduct experiments, as well as analyse and interpret data

Module:1	**Introduction to Electric Drives:**	**3 hours**
Fundamentals of Electric Drive dynamics- Stator and Rotor-Power and Torque-Efficiency-Typical Operating Conditions-Speed Control of Electrical Motors-Reversing-Torque Control-Dynamic braking-Motor Heating and Thermal monitoring.		
Module:2	**Sizing and Selection of Converters:**	**4 hours**
Direct Converters-Converters with Intermediate Circuit-Inverter Modulation Principles-Converter Rating from Motor Specification-Overload Capacity-Control Range-Derating factor-Regenerative Energy.		
Module:3	**Control of DC Drives:**	**5 hours**
Conventional methods of DC motor speed control, single phase and three phase controlled DC drives-four quadrant operation-Chopper fed DC drives-Braking and speed reversal-Closed-loop control of DC Drives-Design of controllers		
Module:4	**Scalar Control of AC Drives:**	**4 hours**
Scalar Control with Compensation - Servo Control – Voltage Vector Control - Standards and Legislations.		
Module:5	**Vector Control of AC Drives:**	**5 hours**
Space Vector Control-Flux Vector Control – Direct torque control – Sensor less control		
Module:6	**EMC and Interference**:	**3 hours**
EMI and EMC- EMC for Power Converters- Grounding and Shielding-Harmonic standards-Harmonic Reduction Methods- Mitigation tools		
Module:7	**Energy Saving in Electric Drives:**	**4 hours**
Classification of Energy Efficiency - Energy Efficient Motor starting and control- Load over Time - Applications with Variable and Constant Torque - Life Cycle Costs and System Savings Using Regenerated Power		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar		

List of Challenging Experiments (Indicative)		
1.	Speed control of Induction Motor Drive using V/F Control	2 hours
2.	Speed control of Induction Motor Drive using VVC	2 hours
3.	Speed control of Induction Motor Drive using Flux Sensor less Control	2 hours
4.	Dynamic braking of Induction Motor Drive	2 hours
5.	Induction motor Equivalent circuit parameters estimation and formation	2 hours
6.	AC Drive Load test using coupled motor-generator setup	2 hours
7.	Speed Control of DC Drive	2 hours
8.	Speed Control of Switched Reluctance Motor (SRM) Drive	2 hours
9.	Different Control Techniques of Servo Drive	2 hours
10.	Speed Control of Slip Ring Induction motor (SRIM)	2 hours
11.	Speed Control of Permanent Magnet Brushless Direct Current Drive (PMBLDC)	2 hours
12.	Speed Control of Permanent Magnet Synchronous Motor Drive (PMSM)	2 hours
13.	Speed Control of Synchronous motor drive using V/F control	2 hours
14.	Speed Control of Synchronous motor drive using flux sensor less control	2 hours
15.	Speed Control of synchronous drive using PI/PID Controller	2 hours
16.	Velocity Control of Linear Induction Motor Drive	2 hours
17.	Performance Estimation of Induction Motor Drive through Multi-Level Inverter	2 hours
18.	Performance Estimation of Induction Motor Drive through Matrix Converter	2 hours
	Total Laboratory Hours	**30 hours**

Text Book(s)	
1.	Bimal K Bose, “Modern Power Electronics and AC Drives”, Pearson Education Asia, 2012.
2.	R. Krishnan, “Electric Motor Drives- Modeling, Analysis and Control”, Prentice Hall Inc., 2008.
Reference Books	
1.	Danfoss Handbook on VLT Frequency Converters, "Facts Worth Knowing about Frequency Converters", PE-MSMBM Publications, 2014
2.	Gopal K dubey, “Fundamentals of Electrical Drives”, CRC Press, Second Edition, 2015
3.	Werner Leonard, “Control of Electric Drives", Springer Verlag, 2012.
4.	Haitham Abu-Rub, Atif Iqbal, Jaroslaw Guzinski, “High Performance Control of AC Drives with Matlab/Simulink Models”, John Wiley & sons, 2012.

Recommended by Board of Studies	**05/03/2016**		
Approved by Academic Council	**40th AC**	Date	**18/03/2016**

EEE5005	**Advanced Semiconductor Devices**	**L**	**T**	**P**	**J**	**C**
		3	**0**	**0**	**0**	**3**
Pre-requisite	**NIL**	**Syllabus version**				
Anti-requisite	**NIL**	v. 1.0				

Course Objectives:

1. To select appropriate devices based on the application requirements.
2. Understand the problems associated with the PE circuits and design protection circuits to overcome these problems.

Expected Course Outcome:

On the completion of this course the student will be able to:

1. Categorize power electronic switches based on its rating and appropriate device selection suitable for application
2. Examine and Classify power diodes based on its switching characteristics
3. Summarize the current controlled devices and synthesize power transistor by building its dynamic model.
4. Select the thyristor suitable for different power ratings and applications.
5. Recognize the voltage controlled devices with emphasis on device paralleling and series operation.
6. Examine and Classify emerging power semiconductor devices.
7. Design appropriate protection circuits to overcome problems associated with power electronic circuits.

Module:1	**Introduction:**	**6 hours**
Power switching devices overview – Attributes of an ideal switch, application requirements, circuit symbols; Power handling capability – (SOA); Device selection strategy – On-state and switching losses – EMI due to switching.		
Module:2	**Power diodes:**	**5 hours**
Structure, operating principle, switching characteristics, types, forward and reverse characteristics, Safe Operating Area (SOA).		
Module:3	**Power Transistors:**	**6 hours**
Construction, static characteristics, physics of operation, switching characteristics; Negative temperature co-efficient and secondary breakdown – Power Darlington- Safe operating regions. dynamic models of BJT		
Module:4	**Power Thyristors:**	**6 hours**
Physics of operation, Two transistor analogy – concept of latching; Gate and switching characteristics; converter grade and inverter grade and other types; series and parallel operation–comparison of BJT and Thyristor – steady state and dynamic models of Thyristor.		
Module:5	**Power MOSFETs and IGBTs:**	**7 hours**
Principle of voltage controlled devices, construction, types, static and switching characteristics, steady state and dynamic models of MOSFET and IGBTs.		
Module:6	**Emerging Power Devices:**	**7 hours**

Basics of GTO, MCT, FCT, RCT and IGCT. Smart power devices, Intelligent Power Modules. Silicon Carbide Devices.				
Module:7	**Gate Driving and Protection:**		**6 hours**	
Necessity of isolation, pulse transformer, opto-coupler – Gate drives circuit for MOSFETs and IGBTs; Design of snubbers–guidance for heat sink selection, heat sink types and design – Mounting types.				
Module:8	**Contemporary issues:**		**2 hours**	
	Total Lecture hours:	**45 hours**		
Text Book(s)				
1.	Ned Mohan, Tore M. Undeland, “Power Electronics – Converters, Applications and Design”, John Wiley & Sons, 2008.			
2.	Rashid M.H., "Power Electronics: Circuits, Devices and Applications ", Pearson Education, June 2013.			
Reference Books				
1.	Robert Perret, “Power Electronics Semiconductor Devices”, John Wiley & Sons,2010.			
2.	Joseph Vithayathil, ‘Power Electronics Principles and Applications’, Tata McGraw-Hill 1st edition, 2010.			
Recommended by Board of Studies	**05/03/2016**			
Approved by Academic Council	**40th AC**	Date	**18/03/2016**	

EEE5006	Integrated Circuits for Power Conversion	L	T	P	J	C
		2	0	2	0	3
Pre-requisite	**NIL**	**Syllabus version**				
Anti-requisite	**NIL**	v. 1.1				

Course Objectives:
1. Enhancing the basic understanding of the using analog circuits related to the analysis of PWM techniques for power converters 2. Imparting experimental design thinking capability in relation to using various PWM techniques in power converter application circuits 3. Extrapolating the design thinking skills to real-time sensors
Expected Course Outcomes:
On the completion of this course the student will be able to: 1. Apply the acquired knowledge in the design of the various PWM technique circuits using operational amplifiers 2. Study of the voltage sensor and current sensor circuits for dc and ac application circuits 3. Analyze the 555 Timer Astable circuits, VCO and PLL circuits. 4. Explain the concepts and of 8 bit DAC and ADC circuits using op-amp. 5. Outline of the knowledge in gate pulse generation for high-frequency converters. 6. Design of the IC voltage regulators circuit for low power real-time applications. 7. Develop the opto driver circuits for MOSFET with 1:N isolation transformer. 8. Design and Conduct experiments, as well as analyze and interpret data.

Module:1	**Op Amp circuits for High-frequency power converters:**	**6 hours**
Introduction to Op-Amp – Linear and Non-Linear applications. Trailing edge, leading edge, and double edge carrier wave generation – Pulse width modulation for power converters-Practical design problems.		

Module:2	**Sensor interfaces for power converters:**	**3 hours**
Design of Signal Gain for AC/DC Voltage and current sensors - practical application circuits with dc to dc and dc to ac converters.		

Module:3	**PLL and 555 Timer circuits for power converters:**	**5 hours**
Voltage controlled oscillator, Phase locked loop (PLL) and synchronization Methods for Grid interfaced converters - Practical circuit using PLL IC. 555 Timer based application circuits		

Module:4	**Mixed-signal circuits for power converters:**	**4 hours**
Generation of PWM for closed loop power converters using analog and digital Integrated circuits - Operation of various ADC and DACs – Practical application circuits.		

Module:5	**Switched Mode RF Power Amplifiers:**	**3 hours**
PWM pulse generation for RF power amplifiers/Resonant converters - Practical circuits.		

Module:6	**Power Supply ICs:**	**4 hours**

Linear Voltage Regulator ICs – fixed and variable voltage regulators – protection schemes – switching regulator ICs – practical biasing circuits for analog and digital ICs.			
Module:7	**High voltage Isolation Interfaces for power converters:**		**3 hours**
Practical design circuit using high-frequency Opto-driver ICs for high voltage - high power converters - Opto-isolator – biasing circuits with 1:N isolation transformer.			
Module:8	**Contemporary issues:**		**2 hours**
	Total Lecture hours:	**30 hours**	
Text Book(s)			
1.	Robert F. Coughlin and Frederick F. Driscoll, "Operational Amplifiers and Linear Integrated Circuits", PHI Learning Private Limited, Sixth Edition, 2015.		
Reference Books			
1.	Robert L. Boylestad and Louis Nashelsky, "Electronic Devices and Circuit Theory", Prentice Hall, Eleventh Edition, 2015.		
2.	Bob Dobkin, Jim Williams, “Analog Circuit Design: A Tutorial Guide to Applications and Solutions”, Elsevier Inc, First Edition, 2011.		
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			

List of Challenging Experiments (Indicative)		
1.	Design and implementation of gate pulses for SΦ inverter using Op-Amp (Single pulse / Multiple pulse / Sinusoidal pulse width modulation)	2 hours
2.	Design and implementation of gate pulses for 3Φ inverter using Op-Amp(Single pulse / Multiple pulse / Sinusoidal pulse width modulation)	2 hours
3.	Design and implementation of gate pulse for boost converter using Op-Amp/ 555 Timer / ICL 8038 / SG2524	2 hours
4.	Design and implementation of gate pulse for buck converter using Op-Amp / 555 Timer / ICL 8038 / SG2524.	2 hours
5.	Design and implementation of gate pulse for buck-boost converter using Op-Amp / 555 Timer / ICL 8038 / SG2524.	2 hours
6.	Design and implementation of gate pulse for sepic converter using Op-Amp / 555 Timer / ICL 8038 / SG2524.	2 hours
7.	Design and implementation of gate pulse for Cuk converter using Op-Amp / 555 Timer / ICL 8038 / SG2524.	2 hours
8.	Design and implementation of gate pulse for buck / boost / buck-boost / interleaved converter using AD632 / AD 633.	2 hours
9.	Design and implementation of gate pulse for cuk / sepic / KY / interleaved converter using Op-Amp / 555 Timer / ICL 8038 / SG2524.	2 hours
10.	Design and implementation of gate pulse for Phase Opposition Disposition (POD) PWM using Quad Op-Amp.	2 hours
11.	Design and implementation of gate pulse for Alternative Phase Opposition Disposition (APOD) PWM using Quad Op-Amp.	2 hours
12.	Design and implementation of gate pulse for Phase Disposition (PD) PWM	2 hours

	using Quad Op-Amp.	
13.	Design and implementation of gate pulse for Phase Shift PWM (PSPWM) using Quad Op-Amp.	2 hours
14.	Design and implementation of gate pulse for Carrier Overlapping PWM (COPWM) using Quad Op-Amp.	2 hours
15.	Design and implementation of gate pulse for Variable Frequency (VFPWM) using Quad Op-Amp.	2 hours
	Total Laboratory Hours	**30 hours**

Recommended by Board of Studies	**22/07/2017**		
Approved by Academic Council	**47th AC**	Date	**05/10/2017**

EEE5007	Intelligent Control	L	T	P	J	C
		3	0	0	0	3
Pre-requisite	**NIL**	**Syllabus version**				
Anti-requisite	**NIL**	v. 1.1				

Course Objectives:

1. Apply neural networks, fuzzy logic and optimization techniques for obtaining improved/desired output(s) from the given power electronic application.
2. Apply the design concepts of feed forward and feedback neural networks for power converters
3. Formulate and analyze the real time power converters with the knowledge of evolutionary algorithms

Expected Course Outcome:

On the completion of this course the student will be able to:
1. Describe the mathematical model of a neuron with different activation functions for power electronic controllers.
2. Demonstrate the concepts of feed forward and recurrent neural networks into travelling salesman problem to find the optimal solution.
3. Apply the hamming and Maxnet training techniques for solving the engineering problems.
4. Analyze the performance of self-organizing feature networks in fourier and wavelet transformations.
5. Estimate the performance of expert systems in modern power controllers.
6. Calculate the membership values with suitable Defuzzification method and the neuro-fuzzy inference systems concept to modern controllers.
7. Design neural network, fuzzy logic and evolutionary based approach for power electronic control

Module:1	**Introduction to intelligent control:**	**5 hours**
Architecture for intelligent control—Symbolic reasoning system—Rule-based systems—Knowledge representation—Expert systems.		
Module:2	**Associative Memories:**	**7 hours**
Basic Concepts – Linear Associator – Basic concepts of recurrent auto associative memory – Associative memory of spatio-temporal patterns – Hetero and Bidirectional Associative Memories - Adaline and Madaline Network Algorithms.		
Module:3	**Networks and Case studies:**	**8 hours**
Hopfield network—Self-organizing network and Recurrent network—ART Network concepts - Neural Network based controller—Stability analysis of Neural—Network interconnection systems—Identification and control of linear and nonlinear		
Module:4	**Data processing:**	**5 hours**
Scaling—Fourier transformation—Principal-component analysis—Wavelet transformations – wavelet tool box		
Module:5	**Fuzzy sets and Fuzzy relations:**	**7 hours**
Introduction to crisp sets and fuzzy sets- basic fuzzy set operation and approximate reasoning - Fuzzy relations—Fuzzification -inferencing and defuzzification—Fuzzy knowledge and rule bases.		
Module:6	**Fuzzy modelling and control:**	**7 hours**
Fuzzy modelling and control schemes for nonlinear systems— Self-organizing fuzzy logic control—Fuzzy logic control for nonlinear time-delay system—Stability analysis of fuzzy control		

systems—Implementation of fuzzy logic controller using Matlab fuzzy-logic toolbox.			
Module:7	**Optimization:**		**4 hours**
Basic concept of optimization— Introduction to evolutionary algorithms- optimization tool box – applications			
Module:8	**Contemporary issues:**		**2 hours**
	Total Lecture hours:	**45 hours**	

Text Book(s)	
1.	Jack M. Zurada, "Introduction to Artificial Neural Systems",Jaico Publishing House, 2013.
2.	Timothy J. Ross, "Fuzzy Logic with Engineering Application",McGrw Hill International Editions, 2012.
Reference Books	
1.	J.S.R Jang, C.T Sun, E.Mizutani, "Neuro-Fuzzy Soft Computing", Pearson Education, 2011.

Recommended by Board of Studies	**22/07/2017**		
Approved by Academic Council	**47th AC**	Date	**05/10/2017**

EEE5008	Modern Control Theory		L	T	P	J	C
			3	0	0	0	3
Pre-requisite	**NIL**	**Syllabus version**					
Anti-requisite	**NIL**	v. 1.0					

Course Objectives:

1. To understand the continuous and discrete state-space modelling of physical systems and apply controllability and observability criteria
2. To understand the concepts and techniques of linear and nonlinear control system analysis and synthesis

Expected Course Outcome:

On the completion of this course the student will be able to:

1. Analyze the system response.
2. Construct the linear model for the Nonlinear system
3. Synthesize the state feedback control law.
4. Estimate the Observer for the given system.
5. Convert the continuous system to discrete model
6. Design digital controller / compensator
7. Examine the system stability

Module	Title	Hours
Module:1	**State Variable Analysis-Continuous system:**	**8 hours**
Introduction to state space modelling- physical systems, State Diagrams, Solution to vector differential equations and state transition matrix. Controllability and Observability.		
Module:2	**Stability Analysis:**	**6 hours**
Stability theory-Linear and Non Linear systems, Lyapunov direct and indirect methods, Lyapunov functions-methods of construction.		
Module:3	**State Feedback Controller Design:**	**6 hours**
Controller design by state feedback –Necessary and Sufficient condition for arbitrary pole placement-state regulator problem. Reference tracking (Servo) problem – State feedback with integral control.		
Module:4	**State Space Observer Design:**	**5 hours**
Full order - reduced order observer design – observer based state feedback control – separation principle.		
Module:5	**Discrete System:**	**6 hours**
Calculus of difference equations. Z-transform, continuous versus digital control, sampling process, effect of sampling rate, Quantization effects. Methods of discretisation- Discrete state variable analysis.		
Module:6	**Stability Analysis of discrete systems:**	**4 hours**
Location of poles, Jury's stability criterion, stability analysis through bilinear transforms.		
Module:7	**Discrete Control Design:**	**8 hours**
Digital compensator design using Root Locus, Frequency Response Plots. Discrete pole placement and observer design.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	K. Ogata, "Modern Control Engineering", Prentice Hall of India, 2010.
2.	G. F. Franklin, J. D. Powell and M Workman, "Digital Control of Dynamic Systems", PHI

	(Pearson), 2008.		
Reference Books			
1.	G. F. Franklin, J. D. Powell and A. E. Naeini, 'Feedback Control of Dynamic Systems' PHI (Pearson), 2004.		
2.	Loan D. Landau, Gianluca Zito, 'Digital Control Systems, Design, Identification and Implementation' Springer, 2006		
3.	D. Ibrahim, 'Micro-controller based Applied Digital Control' John Wiley & Sons Ltd., 2006		
4.	C.T. Chen, 'Linear Systems Theory and Design'' Oxford University Press, 3rd Edition, 1999		
Recommended by Board of Studies	**05/03/2016**		
Approved by Academic Council	**40th AC**	Date	**18/03/2016**

EEE5009	Energy Storage Systems	L	T	P	J	C
		3	0	0	0	3
Pre-requisite	**NIL**	**Syllabus version**				
Anti-requisite	**NIL**	v. 1.1				

Course Objectives:

1. To define different energy storage techniques
2. To describe basic physics, chemistry, and engineering issues of energy storage devices, such as batteries, thermoelectric convertors, fuel cells, super capacitors
3. To design of energy storage for different applications

Expected Course Outcome:

On completion of the course, the student will be able to

1. Identify different energy storage techniques and recent trends
2. Compare different battery technologies and its characters
3. Inspect a modern battery technologies
4. Discuss and combine super capacitors with batteries
5. Analyze fuel cells
6. Identify the different fields of applications of ESS
7. Discuss the applications of energy storage in PV

Module:1	**Introduction:**	**7 hours**

Mechanical, electrical and chemical energy storage systems and its applications - Available and unavailable energy - Energy Analysis - Second law efficiency - Helmholtz & Gibb's function - Energy Analysis - Recent trends in Energy storage systems.

Module:2	**Classical Battery:**	**6 hours**

Basic Concepts - Battery performance - charging and discharging - storage density - energy density and safety issues - Lead Acid- Nickel-Cadmium - Zinc Manganese dioxide.

Module:3	**Modern batteries:**	**5 hours**

Zinc-Air - Nickel Hydride - Lithium Battery - State Of Charge - Technology Challenges.

Module:4	**Super capacitors:**	**7 hours**

Super capacitors - types of electrodes and some electrolytes- Electrode materials – high surface area activated carbons- metal oxide- and conducting polymers- Electrolyte - aqueous or organic- disadvantages and advantages of super capacitors - Applications of Super capacitors

Module:5	**Fuel cells:**	**7 hours**

Fuel cells - direct energy conversion - maximum intrinsic efficiency of an electrochemical converter- physical interpretation - Carnot efficiency factor in electrochemical energy convertors - types of fuel cells - hydrogen oxygen cells - hydrogen air cell - alkaline fuel cell- and phosphoric fuel cell.

Module:6	**Mobile Applications and Micro-Power Sources:**	**5 hours**

The diverse energy needs of mobile applications -Characteristics due to the miniaturized scale - Capacitative storage-electrochemical storage - Hydrocarbon storage- Pyro-electricity - Radioactive source - Recovering ambient energy

Module:7	**Energy Storage in Photovoltaic Systems:**	**6 hours**

Standalone photovoltaic systems - Grid connected systems- Energy Storage in PV systems using lead acid battery technology- Flywheels - Compressed Air Energy Storage - Thermal energy storage -

capturing heat and cold to create energy on demand - Pumped Hydro power.			
Module:8	**Contemporary issues:**		**2 hours**
	Total Lecture hours:	**45 hours**	
Text Book(s)			
1.	Yves Brunet, “Energy Storage", Wiley-ISTE, 1st Edition, 2010.		
2.	Robert A.Huggins, “Energy Storage”, Springer, 2nd Edition, 2015.		
Reference Books			
1.	Andrei G. Ter-Gazarian, "Energy storage systems for Power systems", 2nd edition, IET 2011.		
2.	R M. Dell, D.A.J. Rand, "Understanding Batteries" RSC Publications, 1st edition, 2012.		
Recommended by Board of Studies	**22/07/2017**		
Approved by Academic Council	**47th AC**	Date	**05/10/2017**

EEE5010	Advanced Power System Protection	L	T	P	J	C
		3	0	0	0	3
Pre-requisite	**NIL**	**Syllabus version**				
Anti-requisite	**NIL**	v. 1.1				

Course Objectives:

1. Explain the principle of operation and working of static relay, digital relay and numerical relay.
2. Discuss the various protection schemes used for power system components
3. Discuss and analyse the protection of FACT devices, HVDC transmission and microgrid.

Expected Course Outcome:

On completion of the course the student will be able to

1. Discuss the constructional details and to analyze the performance characteristics of both conventional and static relays.
2. Identify appropriate protection scheme to provide protection to different power system components.
3. Design the protection schemes to provide protection for various FACTS devices.
4. Analyze and design protection schemes to provide protection for the HVDC transmission against over currents and over voltages.
5. Design the adaptive protection scheme for providing protection to Microgrid systems
6. Develop and formulate the algorithm of different types of digital relays.
7. Design the hardware of numerical algorithm and develop the algorithm for it.

Module:1	**Philosophy of Protection:**	**7 hours**

Characteristic functions of protective relays - relay elements and relay terminology- construction of static relays - non-critical switching circuits- Static Relay.

Module:2	**Protection of Power System Components:**	**7 hours**

Protection of generators – transformer over current protection- long EHV line protection- protection of capacitors in an interconnected power system.

Module:3	**Protection of FACTS Devices:**	**7 hours**

TCR Overcurrent Limiter - TCSC Protection - bypass breakers- Capacitor overvoltage protection – Impacts of FACTS devices on distance protection scheme

Module:4	**Protection of HVDC:**	**6 hours**

Converter Faults and protection – protection against over currents – over voltages - protection of DC line.

Module:5	**Microgrid Protection:**	**7 hours**

Key protection challenges- Possible solutions- case Studies: Fault level modification, Blinding of protection, Adaptive protection for microgrids- Fault current source for effective protection in islanded operation- Islanding Detection.

Module:6	**Digital relays:**	**4 hours**

Over current, directional, impedance, reactance relays - digital relaying algorithms.

Module:7	**Numerical relay:**	**5 hours**

Introduction, hardware and protection schemes and algorithms.

Module:8	**Contemporary issues:**	**2 hours**

	Total Lecture hours:		**Hours: 45**	
Text Book(s)				
1.	Paithankar and S. R Bhide, "Fundamentals of Power System Protection", Prentice-Hall of India, 2013			
2.	Paul M Anderson, "Power System Protection" , Wiley-IEEE Press, 2012'			
Reference Books				
1.	Suleiman M. Sharkh, Mohammad A. Abu-Sara, Georgios I. Orfanoudakis, Babar Hussain, "Power Electronic Converters for Microgrids", John Wiley & Sons, 2014.			
Recommended by Board of Studies	**22/07/2017**			
Approved by Academic Council	**47th AC**	Date	**05/10/2017**	

EEE5011	Protocols for Smart Grid	L	T	P	J	C
		3	0	0	0	3
Pre-requisite	**NIL**	**Syllabus version**				
Anti-requisite	**NIL**	v. 1.0				

Course Objectives:

1. To familiarize with the working and features of smart grid
2. To understand the various communication technologies for Smart grid
3. To understand the standards and protocols for smart grid

Expected Course Outcome:

1. Identify the importance of smart grid as compared to a conventional ac grid.
2. Illustrate the importance and application of Phasor measuring unit
3. Recognize the importance of management of power demand in grid
4. Describe the various security issues related to smart grid
5. Outline the management of data in smart grid environment
6. Apply the various control aspects to smart grid
7. Summarize the communication /information technology protocols used smart grids.

Module:1	**Introduction:**	**5 hours**

Electric grid-Grid Topologies- Microgrid concept- Justifications for smart grids-Differences between the conventional grid and smart grid-Working definition of smart grid based on performance measures-Functions of smart grid components-Monitoring and Control Technology component-Intelligent Grid Distribution component-Demand Side Management.

Module:2	**Measurement Technology:**	**6 hours**

Monitoring, Phasor Measurement Units(PMU) Working and applications-Optimal placement of PMU-Fault Detection and Self healing-smart meters-an overview of the hardware used-Demand Side Integration-smart appliances-Advanced Metering Infrastructure-Multiagent Systems for smart grid implementation

Module:3	**Information and Communications Technology:**	**9 hours**

Data Communication-dedicated and shared communication channels-GSM,GPRS,3G-WiMax,Zigbee Coordination between cloud computing and smart power grids-Development of power system models and control and communication Software

Module:4	**Interoperability, Standards and Cyber Security:**	**6 hours**

State of the art interoperability-Benefits and challenges of interoperability-Smart grid network interoperability-Cyber Security concerns associated with AMI.

Module:5	**Standards for Smart Grid Operations**:	**6 hours**

IEC standards for substation automation-IEC 61850-IEC standard for energy management systems-IEC 61970-ANSI C12.22 for Smart metering.

Module:6	**Standards for Communication Protocols:**	**6 hours**

Providing Common information model- IEC 60870-IEC 62351-High Speed Power Line communication-IEEE P1901**.**

Module:7	**Smart Grid Operations:**	**5 hours**

SCADA (supervisory control and data acquisition) Functions and function architecture -

Configuration Management- Fault Management -Accounting Management Security Management Data and data architecture-Common Information Model (CIM) Process architecture				
Module:8	**Contemporary issues:**		**2 hours**	
	Total Lecture hours:	**45 hours**		
Text Book(s)				
1.	James A.Momoh, "Smart grid: Fundamentals of Design and Analysis", IEEE press and Wiley publications, 2012.			
2.	Janaka Ekanayake, Kithsiri Liyanage,Jianzhong Wu,Akihiko Yokoyama,Nick Jenkins, "Smart Grid Technology and Applications", Wiley 2011.			
Reference Books				
1.	Hassan Farhangi, "The path of the smart grid", IEEE power and Energy Magazine, Vol.8, No.1, Jan 2010.			
Recommended by Board of Studies	**05/03/2016**			
Approved by Academic Council	**40th AC**	Date	**18/03/2016**	

EEE5031	Advanced Reliability Engineering	L	T	P	J	C
		1	2	0	0	2
Pre-requisite	**NIL**	**Syllabus version**				
Anti-requisite	NIL	v. 1.0				

Course Objectives:

1. Apply the principles & methods of reliability and maintenance engineering tools for Design problems
2. Understand the importance of reliability and its relationship with quality and safety
3. Application of RAMS to Aero, Medical and Industrial commodities

Expected Course Outcome:

On the completion of this course the student will be able to:

1. Design RAMS as per the standards followed for AERO applications.
2. Develop models and case studies to analyze RAMS for medical devices.
3. Design to meet the reliability and functional safety objectives in the Auto components.
4. Examine the various reliability test strategies and standards for Industrial systems.
5. Analyze RAMS in the user specific applications.
6. Integrate different case studies for the utilizations of RAMS in specific applications.
7. Develop the reliability predictive models using software tools.

Module:1	**RAMS - AERO**	**5 hours**

RAMS in Aerospace Domain, ARP 4761 and ARP 4754 - System Safety Assessment Process. Introduction to DO-178, DO-254 and DO - 160 E Standards. Process FMEA, MSG 3 Analysis, RAMS Case Study on Aero Program.

Module:2	**RAMS - MEDICAL**	**5 hours**

RAMS in Medical Domain, Medical Devices - Classification and Applicable Reliability and Risk Management Tasks, Standards - ISO 14971, ISO 13485. PMS - Post Market Surveillance in Medical Devices - RAMS Case Study on Medical Devices

Module:3	**RAMS - AUTO**	**4 hours**

RAMS in Auto Domain, DFR Process in Auto Domain, ISO 26262 - Functional Safety, ITAF 16949 Standard. Warranty Data Management. RAMS Case Study - Auto Systems.

Module:4	**RAMS - INDUSTRIAL, ROBOTS**	**4 hours**

RAMS in Industrial Domain, IEC 61508 - Functional Safety Standard. RAMS Case Study on Industrial Systems.

Module:5	**RAMS - APPLIANCES, OFFICE AUTOMATION PRODUCTS, CONSUMER ELECTRONICS**	**4 hours**

RAMS in Appliances, Office Automation Product and Consumer Electronics - Case Study From Each Domain.

Module:6	**TUTORIALS- I**	**4 hours**

Domain Specific Reliability and Safety Plan

Module:7	**TUTORIALS – II**		**4 hours**
Reliability Test Planning - Reliasoft ALTA++ Test Planning, Test Data Analysis			
Module:8	**Contemporary issues:**		**2 hours**
	Total Lecture hours:	**30 hours**	
Text Book(s)			
1.	Louis J. Gullo and Jack Dixon, "Design for Safety-Quality and Reliability Engineering Series", John Wiley & Sons, 2017.		
Reference Books			
1.	B S Dhillon, "Robot System Reliability and Safety: A Modern Approach", CRC Press-Taylor & Francis, 2015.		
2.	Nicholas J. Bahr, "System Safety Engineering and Risk Assessment: A Practical Approach", Second Edition, CRC Press-Taylor & Francis, 2015.		
3.	Richard C. Fries, "Reliable Design of Medical Devices", Third Edition, CRC Press-Taylor & Francis, 2013.		
4.	Clifton A. Ericson II, "Hazard Analysis Techniques for System Safety", First Edition, John Wiley & Sons, 2005.		
Mode of Evaluation**:** CAT / Assignment / Quiz / FAT / Project / Seminar			
Recommended by Board of Studies	**13-10-2018**		
Approved by Academic Council	**53rd**	Date	**13-12-2018**

EEE6002	**Wind Energy Conversion Systems**		**L**	**T**	**P**	**J**	**C**
			2	**0**	**0**	**4**	**3**
Pre-requisite	**EEE5002**	**Syllabus version**					
Anti-requisite	**NIL**	v. 1.0					

Course Objectives:

1. To study different types of generators and appropriate power electronic controllers for wind energy systems

Expected Course Outcome:

On the completion of this course the student will be able to:

1. Outline the basic concepts of wind turbine and its characteristics.
2. Discuss about all the control methods of wind turbines.
3. Construct the various generator configurations used in WECS.
4. Analyse about power converters and its control techniques.
5. Develop the grid integrated operation.
6. Solve the power quality issues and recommend the standards.
7. Summarise the offshore wind power generation.
8. Design a component or a product applying all the relevant standards with realistic constraints

Module:1	**Introduction:**	**4 hours**

Aerodynamic Principles – Design – Betz limit – Components and Types of Turbine – Operating characteristics – Wind power – Factors – Power limitations

Module:2	**Control of Wind Turbines:**	**4 hours**

Pitch Control –stall control – Combined Pitch-stall control – Flap power control – yaw control – Electrical braking – mechanical braking – MPPT Schemes

Module:3	**Generator Configuration:**	**4 hours**

Asynchronous - Doubly fed – fully fed - Synchronous - Permanent magnet-drive train.

Module:4	**Power Electronic Interface and Control:**	**4 hours**

Wind Converter Configurations – DFIG - Control of Machine Side and Grid Side Converters; Elimination of GSC - Real Power Control

Module:5	**Grid Integration:**	**4 hours**

Wind interconnection requirements, low-voltage ride through (LVRT), ramp rate limitations, and supply of ancillary services for frequency and voltage control, current practices and industry trends wind interconnection- impact on steady-state and dynamic performance.

Module:6	**Power Quality Issues and Standards:**	**4 hours**

Factors – Power Quality Standards and Regulations, Issues and Consequences - Mitigation Techniques and Control

Module:7	**Offshore Wind Energy:**	**4 hours**

Typical Subsystems – Turbine Technology – Transmission network – HVAC and HVDC – Impact on Power system – Energy Storage – Sub-sea station – Condition monitoring.

Module:8	Contemporary issues:		2 hours
	Total Lecture hours:	30 hours	
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
List of Projects			
1. Modeling of Vertical Axis Wind Turbine			
2. Modeling of Horizontal Axis Wind Turbine			
3. Modeling of MPPT Techniques			
4. Modeling of Generators			
5. Modeling of Power Electronics Interface			
6. Modeling of Grid Side Converters in DFIG			
7. Modeling of Machine Side Converters in DFIG			
8. Steady state and transient analysis wind generators			
9. Frequency Control in Wind turbines			
10. Power Quality mitigation of Wind turbines			
11. Power Optimization of Wind turbines			
12. Wind Speed Estimation Techniques			
13. Power Curve formation of Wind turbines			
14. Modeling of Energy storage devices			
15. Response of Controller under normal and fault conditions			

Text Book(s)	
1.	Bin Wu, Yongqiang Lang, Navid Zargari, Samir Kouro, “Power Conversion and Control of Wind Energy Systems”, John Wiley & Sons, 2011.
2.	Siegfried Heier, “Grid Integration of Wind Energy Conversion Systems”, Wiley, 2009.
Reference Books	
1.	Thomas Ackkermann, “Wind Power in Power Systems”, John Wiley & Sons, Ltd, 2012.
2.	D. P. Kothari, S. Umashankar, “Wind Energy Systems and Applications”, Narosa Publications, Newdelhi, 2014.
3.	Olimpo Anaya-Lara, David Campos-Gaona, Edgar Moreno-Goytia, Grain Adam, “Offshore Wind Energy Generation: Control, Protection, and Integration to Electrical Systems”, John Wiley & Sons, 2014.

Recommended by Board of Studies	**05/03/2016**		
Approved by Academic Council	**40th AC**	Date	**18/03/2016**

EEE6003	Power Quality and Mitigation Techniques	L	T	P	J	C
		2	0	0	4	3
Pre-requisite	**EEE5001**	**Syllabus version**				
Anti-requisite	**NIL**	v. 1.0				

Course Objectives:

1. To describe various power quality issues in power system
2. To analyze the power quality issues using appropriate techniques
3. To give an insight to various measurement techniques and conduct power quality analysis
4. To evaluate and implement various mitigation techniques for power quality improvement

Expected Course Outcome:

On successful completion of the module, students will be able to:

1. Define and Describe power quality issues as per IEEE /IEC standards
2. Simulate and Analyze voltage sag, swell and interruption and Describe methods to reduce sag and swell
3. Analyze single and three phase loads for improving power factor, harmonics and unbalanced loads
4. Analysis of harmonics by mathematical tools
5. Apply of IEEE/IEC power quality standards for measurements and analysis
6. Design of filters and compensators for harmonic reduction, load balancing and power factor improvement
7. Evaluate power quality at an Industry/Data centre/Hospital and Develop solution
8. Design a component or a product applying all the relevant standards with realistic constraints

Module:1	INTRODUCTION TO POWER QUALITY:	4 hours

Terms and definitions: Overloading - under voltage - over voltage. Concepts of transients - short duration variations such as interruption - long duration variation such as sustained interruption. Sags and swells - voltage sag - voltage swell - voltage imbalance - voltage fluctuation - power frequency variations. Power Acceptability curves – Power Quality Standards, limits and regulations.

Module:2	VOLTAGE SAGS AND SWELLS:	4 hours

Sources of sags and interruptions - Estimating Voltage Sag Performance -Fundamental Principles of Protection -Solutions at the End-User Level-Evaluating the Economics of Different Ride-Through Alternatives -Motor-Starting Sags - Utility System Fault-Clearing Issues, Sources of over voltages - Capacitor switching – Ferro resonance. Mitigation of voltage swells - surge arresters

Module:3	ANALYSIS OF SINGLE PHASE AND THREE PHASE LOADS:	4 hours

Power in single phase systems: Sinusoidal voltage, non-sinusoidal voltage – Power in three phase systems: Balanced & unbalanced loads – phasor analysis – three phase unbalanced and distorted source supplying nonlinear loads – concept of power factor under non-sinusoidal voltages and/or currents.

Module:4	CONVENTIONAL LOAD COMPENSATION TECHNIQUES:	4 hours

Analysis of unbalance – symmetrical components, instantaneous real and reactive powers - Principle of load compensation and voltage regulation – classical load balancing problem: open loop balancing – closed loop balancing, current balancing.

Module:5	**HARMONIC ANALYSIS:**	**5 hours**
Principles for Controlling Harmonics - Harmonic analysis using mathematical tools – Computation of THD, TDD, DIN – Extraction of fundamental sequence component from measured samples.		
Module:6	**FILTER DESIGN:**	**4 hours**
Harmonic Reduction: Design of passive filter – performance evaluation and rating of filters - Instantaneous real and reactive power theory - shunt active filter - series active filter - reference current generations - Instantaneous symmetrical component theory - realization of DSTATCOM, UPQC energy.		
Module:7	**POWER QUALITY MONITORING AND SURVEY:**	**3 hours**
Monitoring Considerations - Power Quality Measurement Equipment-Assessment of Power Quality Measurement Data-Application of Intelligent Systems-Power Quality Monitoring Standards.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar		

List of Projects

1. Power Quality Analysis of residential loads
2. Power Quality Analysis of UPS loads
3. Power Quality Analysis of AC Plant / computer loads
4. Power Quality Analysis of loads in a computer lab
5. Power Quality Analysis of Sewage Treatment Plant
6. Power Quality Analysis of Substation Power house
7. Modeling of CFL/LED Lighting loads
8. Modeling of UPS
9. Modeling of Transformer and Tap changers
10. Modeling of Reactive power compensation devices
11. Investigations of Power Quality Events
12. Investigations of Energy Loss in the electrical network
13. Case Studies and Reports on effect of diesel generators on power quality parameters in an electrical network grid
14. Case Studies and Reports on effect of renewables on power quality parameters in an electrical network grid

Text Book(s)

1.	Roger C. Dugan, Mark F. McGranaghan, Surya Santoso, H. Wayne Beaty, “Electrical Power System Quality”, Tata Mcgraw-hill, Newdelhi, 2012
2.	Mohammad A.S Masoum, Ewald F.Fuchs, “Power Quality in Power Systems and Electrical Machines”, Academic Press, Elsevier, 2015.

Reference Books

1.	Ghosh and G. Ledwich, “Power Quality Enhancement Using Custom Power Devices”, Springer Verlag, 2012.

2.	Surajit Chattopadhyay, Madhuchhanda Mitra, Samarjit Sengupta,"Electric Power Quality", Springer Publications, 2011
3.	Bhim Singh, Ambrish Chandra, Kamal Al-Haddad, "Power Quality: Problems and Mitigation Techniques", John Wiley & sons Ltd, 2015.

Recommended by Board of Studies	**05/03/2016**		
Approved by Academic Council	**40th AC**	Date	**18/03/2016**

EEE6004	**Microgrid Technologies**	**L**	**T**	**P**	**J**	**C**
		3	**0**	**0**	**0**	**3**
Pre-requisite	**EEE5001**	**Syllabus version**				
		v. 1.1				

Course Objectives:

1. Understand the integration of renewable sources
2. Design modern control technologies for microgrids in Islanded and grid connected operation

Expected Course Outcome:

1. Basic understanding of the microgrid types and configurations
2. Applications of power electronics in Microgrid and acquire the knowledge of multifunction grid connected converters
3. Analyse the various types of control in micro grid in islanded and grid connected operation
4. Study the energy management concept in grid connected a and islanded microgrid
5. Categorize the issues in Microgrid technologies and study the impact of DG's
6. Design an optimized Microgrid considering the role of power market
7. Identifying the necessity of protection and detecting the islanding operation in Microgrid

Module:1	**Introduction to Microgrid**	**5 hours**
Microgrid Configurations – CERTS Microgrid Test Bed – DC Microgrid- HFAC Microgrid – LFAC Microgrid – Hybrid DC- and AC- Coupled Microgrid		
Module:2	**Power Electronics in Microgrid**	**6 hours**
Grid Connected Mode – Islanded mode – Battery Charging mode – design of power converters– Brick Busses Software Frame work- Multi Function grid Connected inverters		
Module:3	**Control in Microgrid**	**6 hours**
Impact of load characteristics – Local control – Centralized Control- Decentralized Control- islanded operation – PQ Control - Droop control methods – Frequency/Voltage Control –Inverter Output Impedance		
Module:4	**Microgrid Energy Management Systems**	**6 hours**
Load Sharing and Power Management Strategy - Stand-alone – Grid connected – energy storage - Voltage Control and Active Power Management		
Module:5	**Power Quality Enhancement**	**6 hours**
Compensators and controllers for power quality issues – Power Quality Improvement technologies – Impact of DG integration on Power Quality.		
Module:6	**Optimization in Microgrid**	**7 hours**
Stochastic Optimization for Operating Cost- Unit Commitment- Congestion Management- Role of Microgrid in Power Market		
Module:7	**Protection in Microgrid**	**7 hours**
Device Discrimination-Islanding detection, Effect on Feeder Reclosure, Protection for an Islanded Microgrid having IIDG Units- Adaptive relaying scheme		
Module:8	**Contemporary issues:**	**2 hours**

	Total Lecture hours:	**45 hours**	

Text Book(s)

1.	Suleiman M,Sharkh, Mohammad A.Abu-Sara Georgios I. Orfanoudakis, Babar Hussain, "Power Electronic Converters for Microgrid", Wiley-IEEE Press, 2014
2.	A.Mahmoud, A.L- Sunni and Faud,M, "Control and Optimization of Distributed Generation Systems"ISBN: 978331916910, Springer Publishers,2015.

Reference Books

1.	Nikos Hatziargyiou, "Microgrids: Architectures and Control" ISBN: 978-1-118-72068-4,Wiley-IEEE Press, December 2013.
2.	S.Chowhury, S.P.Chowdury and Peter Crossley, "Microgrids and Active Distribution Networks" ISBN978-1-84919-014-5, IET renewable Energy series, 2011.
3.	Ritwi K Majumder, "Microgrid: Stability Analysis and Control" VDM Publishing 2010
4.	Shin'ya Obara, "Optimum Design of Renewable Energy Systems: Microgrid and Nature Grid Methods", AEEGT Book Series, 2014

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

Recommended by Board of Studies	**22/07/2017**		
Approved by Academic Council	**47th AC**	Date	**05/10/2017**

		L	T	P	J	C
EEE6005	**Electric and Hybrid Electric Vehicles**	**L**	**T**	**P**	**J**	**C**
		2	**0**	**0**	**4**	**3**

Pre-requisite	**EEE 5001**	**Syllabus version**
Anti-requisite	**NIL**	v. 1.0

Course Objectives:

1. Providing knowledge on Hybrid and Electric vehicles
2. Selection of suitable motor drive and power converters for Electric vehicle application

Expected Course Outcome:

On the completion of this course the student will be able to:

1. Understand the necessity of Electric vehicles and environmental issues of conventional vehicles
2. Describe the performance characteristics of Electric vehicles
3. Compare different architectures of hybrid power trains
4. Analyse the power flow management of Hybrid electric vehicles
5. Examine the characteristics of different electric motors for Electric vehicle application
6. Select the sizing of the motor and power electronic components for Electric and hybrid electric vehicles
7. Develop different energy management strategies for electric vehicles.
8. Design a component or a product applying all the relevant standards with realistic constraints

Module:1	**Introduction to Hybrid Electric Vehicle**	**4 hours**
History of hybrid and electric vehicles - social and environmental importance of hybrid and electric vehicles - modern drive - trains on energy supplies and their impact.		
Module:2	**Electrical Vehicle model and Characteristics**	**4 hours**
Basics of vehicle performance - vehicle power source characterization – transmission characteristics - mathematical models to describe vehicle performance		
Module:3	**Hybrid Train Architectures**	**4 hours**
Fundamental concept of hybrid traction - Basic concepts of electric traction - introduction to various electric drive - train topologies.		
Module:4	**Power Flow Management**	**4 hours**
Introduction to various hybrid drive-train topologies – Power flow control in hybrid drive - train topologies - fuel efficiency analysis		
Module:5	**Electric Machine and Drive in Hybrid Electric Vehicles**	**4 hours**
Configuration and control of DC Motor drives - AC Motor drives - Permanent Magnet Motor drives - Switch Reluctance Motor drives		
Module:6	**Performance Analysis of Hybrid Electric Vehicles**	**4 hours**
Matching the electric machine and the internal combustion engine (ICE) - Sizing the propulsion motor - power electronic components - selecting of energy storage technology- communications – supporting subsystems		
Module:7	**Energy Management Strategies**	**4 hours**
Introduction to energy management strategies used in hybrid and electric vehicle - classification of different energy management strategies - comparison of different energy management strategies - implementation issues of energy strategies		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)

1.	Chris Mi, MA Masrur, and D W Gao, "Hybrid Electric Vehicles- Principles and Applications with Practical Perspectives", Wiley, 2011.
2.	Iqbal Hussain, "Electric and Hybrid Vehicles-Design Fundamentals", CRC Press, Second Edition,2011.
Reference Books	
1.	Mehrdad Ehsani, Yimin Gao, and Ali Emadi, "Modern Electric, Hybrid and Fuel Cell Vehicles: Fundamentals", CRC Press, 2010.
2.	Davide Andrea, "Battery management Systems for Large Lithium-Ion Battery Packs", Artech House, 2010.

Mode of Evaluation:	CAT I & II – 30%, DA – 10%, Quiz-I & II – 20%, FAT – 40%		
Recommended by Board of Studies	**05/03/2016**		
Approved by Academic Council	**40th**	Date	**18/03/2016**

EEE6006	High Voltage Direct Current Transmission	L	T	P	J	C
		3	0	0	4	4
Pre-requisite	**EEE5001**	**Syllabus version**				
Anti-requisite	**NIL**	v. 1.0				

Course Objectives:

1. Describe various HVDC Transmission system technology with details
2. Analysis and control of HVDC converters
3. Modeling and dynamic analysis of HVDC systems through simulations
4. Fault analysis and system interaction of HVDC system

Expected Course Outcome:

On the completion of this course the student will be able to:

1. Evaluate HVAC and HVDC technology with techno-economic aspect
2. Describe HVDC Transmission system through single-line diagram
3. Modeling and Simulation of HVDC Converters
4. Analysis of HVDC Converters
5. Design of Harmonic Filters for HVDC Systems
6. Simulation & Analysis HVDC Faults through MATLAB/CYME
7. Study of a national HVDC Project and preparation of report in LaTeX
8. Design a component or a product applying all the relevant standards with realistic constraints

Module:1	**DC Power Transmission Technology:**	**10 hours**
Comparison of AC and DC transmission - HVDC transmission –planning for HVDC transmission-modern trends in HVDC transmission - IEEE and IEC standards.		
Module:2	**Analysis of HVDC converters:**	**7 hours**
Pulse number - choice of converter configuration-simplified analysis of Graetz circuit-converter bridge characteristics – characteristics of a twelve pulse converter- analysis of converters		
Module:3	**Control of HVDC System:**	**5 hours**
Principles of control - converter firing control - Valve blocking and bypassing - starting, stopping, and power flow reversal		
Module:4	**Modeling of HVDC System:**	**6 hours**
Per unit system for dc quantities - power flow solution - stability studies		
Module:5	**Dynamics of HVDC system:**	**5 hours**
HVDC system modelling for digital dynamic simulation		
Module:6	**HVDC system interactions:**	**6 hours**
Short circuit ratio - reactive power and ac system strength - problems with low ESCR system - problems associated with weak systems - effective inertia constant		
Module:7	**Response to DC and AC system faults:**	**4 hours**
DC line faults - converter faults – protection		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
List of Projects			
1. Design a block describing HVDC transmission system			
2. Design a block describing valve control of HVDC converter station			
3. Design a block describing Valve control of HVDC inverter station			
4. Design a block describing PLL for synchronising			
5. Design a block describing instantaneous active power measurement			
6. Design a block describing instantaneous reactive power measurement			
7. Design a Simulation block of HVDC transmission line			
8. Design a Simulation circuit HVDC converter valve operation			
9. Design a Simulation circuit of HVDC inverter valve operation			
10. Develop a linearized model of HVDC transmission line			
11. Develop a linearized model of AC/DC interactive HVDC system			
12. Develop a linearized model of filter circuit			
13. Design a three phase Graetz converter circuit			
14. Develop steady state flow model of HVDC power system			
15. Develop a block describing generalised filter circuit model			

Text Book(s)

1.	Chan-Ki Kim, Vijay K. Sood, Gil-Soo Jang, Seong-Joo Lim, Seok-Jin Lee, "**HVDC Transmission Power Conversion Applications in Power Systems"**, John Wiley, Singapore, 2009.
2.	Jos Arillaga, **HVDC Transmission**, 2nd Edition, IET, London, UK, 1998.

Reference Books

1.	Edward Wilson Kimbark, "**Direct Current Transmission**", Vol. I, Wiley Inter Science, New York, London, Sydney, 1971.
2.	Padiyar, K.R., "**HVDC Power Transmission System**", Wiley Eastern Limited, New Delhi, 2010.

Recommended by Board of Studies	**05/03/2016**		
Approved by Academic Council	**40th AC**	Date	**18/03/2016**

EEE6007	Pulse Width Modulation and Control	L	T	P	J	C
		2	0	0	4	3
Pre-requisite	**EEE5001**	**Syllabus version**				
Anti-requisite	**NIL**	v. 1.0				

Course Objectives:

1. To understand the importance of pulse width modulation (PWM) technique applied to power converters.
2. To implement various PWM strategies.

Expected Course Outcomes:

On the completion of this course the student will be able to:

1. Design of the use of various PWM techniques applied to power electronic converters.
2. Study of the concept of single phase and three phase VSI.
3. Apply the concept of voltage control inverters using various pwm techniques.
4. Analyze the concept of modulation control of inverters.
5. Discuss of the advanced modulation technique for inverters.
6. Understand the various pwm techniques using in multi-level inverters.
7. Apply the concept of harmonic in inverters.
8. Design a component or a product applying all the relevant standards with realistic constraints

Module:1	**Introduction:**	**3 hours**

Fundamentals of PWM – Base and carrier signal generation - Methods of implementation – Driver circuits for interfacing - PWM control of DC-DC converters.

Module:2	**Three Level Modulation of 1ϕ VSI:**	**3 hours**

Topology of a 1ϕ VSI – three level modulation of 1ϕ VSI –- analytical calculation of harmonic losses.

Module:3	**Voltage Control of 1ϕ VSI:**	**3 hours**

Single, Multiple, Sinusoidal and Modified Sinusoidal PWM techniques –Impact of Power device on the PWM technique expression for output voltage.

Module:4	**Modulation of 3ϕ VSI:**	**5 hours**

Topology of a 3ϕ VSI – 3ϕ modulation with sinusoidal references – Third harmonic reference injection – analytical calculation of harmonic losses – over modulation operation – Analysis of total harmonic distortion for various operating conditions

Module:5	**Advanced Modulation Techniques:**	**4 hours**

Trapezoidal, Staircase, Stepped, Harmonic Injection and Delta modulation techniques – Space Vector Modulation (SVM) – Implementation issues involved in the modulation schemes

Module:6	**Modulation Strategies for Multi-Level Inverters (MLI):**	**5 hours**

Basics of carrier based PWM techniques for MLIs – Three level naturally sampled Phase Disposition PWM (PDPWM) – Three level naturally sampled Phase Opposition Disposition PWM (PODPWM) – Alternative Phase Opposition Disposition PWM (APODPWM) technique – Introduction to reduced

switch multilevel inverters.		
Module:7	**Harmonic Elimination:**	**5 hours**
Methods of harmonic elimination - Harmonic elimination applied to MLIs – Switching angle computations with equal and unequal voltage levels – minimum harmonic distortion.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar		

List of Projects	
1. Implementation of Time Ratio Control (TRC) of DC-DC Converter.	
2. Implementation of Current Limit Control (CLC) of DC-DC Converter.	
3. Design and implementation of an un-modulated (square wave) voltage source inverter (VSI).	
4. Design and implementation of sinusoidal pulse width modulated (PWM) voltage source inverter (VSI).	
5. Design and implementation of three level modulated voltage source inverter (VSI).	
6. Measurement and validation of harmonic profile of single phase VSI under various modulation techniques.	
7. Design and implementation of three phase VSI under 120° mode.	
8. Design and implementation of three phase VSI under 180° mode.	
9. Measurement and validation of harmonic profile of three phase VSI under various modulation techniques.	
10. Implementation of Trapezoidal PWM and space vector modulation (SVM) technique for three phase VSI.	
11. Implementation of selective harmonic elimination technique.	
12. Pulse generation for three level naturally sampled PDPWM.	
13. Pulse generation for three level naturally sampled PODPWM.	
14. Pulse generation for APODPWM technique.	
15. Validation of harmonic profiles of MLI’s controlled using PDPWM, PODPWM and APODPWM methods.	

Text Book(s)	
1.	D.Graham Holmes and Thomas A. Lipo, “Pulse Width Modulation for Power Converters – Principles and Practice”, John Wiley & Sons, 2003.
Reference Books	
1.	Bin Wu, “High-Power Converters and AC Drives”, John Wiley & Sons, 2006.
2.	Rashid M.H., “Power Electronics: Circuits, Devices and Applications”, Pearson Education, June 2013.
3.	Ned Mohan, Tore M. Undeland, “Power Electronics – Converters, Applications and Design”, John Wiley & Sons, 2007.

Recommended by Board of Studies	**05/03/2016**		
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EEE6008	Solar Photo Voltaic Systems	L	T	P	J	C
		2	0	0	4	3
Pre-requisite	**EEE5001**	**Syllabus version**				
Anti-requisite	**NIL**	v. 1.0				

Course Objectives:

1. To make the students to understand the importance and applications of Solar Energy and techniques to improve the efficiency of Solar PV system.
2. To make them acquainted with power electronic interface circuits for Solar Energy

Expected Course Outcome:

On the completion of this course the students will be able to:

1. Apply new techniques for estimation of solar PV cell parameters
2. Capability to assess the performance of solar thermal power plants
3. Develop new tracking techniques and reconfiguration methods for improved power extraction from solar PV systems
4. Design a photovoltaic system and its interfacing circuits
5. Synthesize PV system architecture for grid connected PV systems and applications of Solar PV in real time scenario.
6. Examine new materials for energy storage as well as for high temperature applications
7. Compute the cost analysis and payback period of solar PV installations and categorize various environmental impacts of PV.
8. Design a component or a product applying all the relevant standards with realistic constraints

Module:1	**Solar PV cell fundamentals:**	**4 hours**

Principle of direct solar energy conversion into electricity in a solar cell - properties - Solar cell and its types - p-n junction, structure- I-V characteristics of a PV module - solar PV modelling and equations - modelling techniques - cell efficiency - fill factor - Applications.

Module:2	**Solar PV plants:**	**3 hours**

Energy Transfer Power cycles - Tower, Trough and Dish Systems - Concentrating Dish Systems - Concentrating Linear Fresnel Reflectors - Solar Chimneys - Hybrid Systems.

Module:3	**Maximum power point tracking:**	**4 hours**

Need for Maximum power tracking- - effect of irradiation and temperature on PV characteristics - Tracking techniques and array reconfiguration

Module:4	**Stand Alone PV Systems:**	**5 hours**

Schematics, Batteries, Charge Conditioners - Balance of system components for DC and/or AC Applications - Typical applications for lighting, water pumping etc.

Module:5	**Grid Connected PV Systems:**	**5 hours**

Schematics - Charge Conditioners - Interface Components - Balance of system - PV System in Buildings.

Module:6	**Energy Storage:**	**5 hours**

Necessity of storage for solar energy- Rechargeable batteries.Solar Energy Storage Concepts - Materials for Energy Storage- Materials for Low and High Temperature Storage Applications.		
Module:7	**Cost Analysis and Environmental Issues:**	**3 hours**
Cost analysis and pay back calculations for different types of solar panels and collectors - installation and operating costs - Environmental and safety issues - protection systems - performance monitoring.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar		
List of Projects:		
1. Identification of suitable materials for effective solar PV cell		
2. Extraction of I-V and PV characteristics of real solar PV panel suing resistive load		
3. Design a model of any solar PV application		
4. Identification of suitable location of establishing solar PV plants		
5. Study on factors which effecting the performance of solar PV systems		
6. How the factors like fill factor and temperature effects on performance of solar PV system		
7. Design control algorithm for Maximum power tracking		
8. Real time implementation of MPP techniques		
9. Simulation of various conventional MPP techniques		
10. Implementation bio inspired algorithms for maximum power tracking		
11. Design of standalone solar PV system using simulation.		
12. A survey on major standalone solar PV systems and applications		
13. Necessity of hybrid systems		
14. Integration of Solar and Battery source in real time interface		
15. Design and implementation of MPP for wind system		

Text Book(s)	
1.	Roger Messenger, Amir Abtahi, “Photovoltaic Systems Engineering”, 3rd edition, CRC Press, 2010.
2.	D. Yogi Goswami , “Principles of Solar Engineering” 3rd Edition, , CRC Press, 2015.
Reference Books	
1.	Leon Freris, David Infield, “Renewable energy in power systems”, John Wiley & Sons, 2008.
2.	Ali Keyhani, “Design of Smart Power Grid Renewable Energy Systems”, John Wiley & Sons, 2011.
3.	Michael Boxwell, “The Solar Electricity Handbook”, Code Green Publishing, UK, 2009.
4.	Sukhatme S.P., “Solar Energy”, Tata McGraw Hills P Co., 3rd Edition, 2008.
5.	R.Mukund, “Wind and Solar Power Systems: Design, Analysis, and Operation”, 2nd Edition, CRC Press, 2005.

Recommended by Board of Studies	**05/03/2016**		
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EEE6009	Special Machines and Control	L	T	P	J	C
		2	0	0	4	3
Pre-requisite	**EEE5002**	**Syllabus version**				
Anti-requisite	**NIL**	v. 1.0				

Course Objectives:

1. To impart knowledge on non-standard type of electro-mechanical energy conversion machines and their importance.

Expected Course Outcome:

On the completion of this course the student will be able to:

1. Analyze permanent magnet material property and circuits
2. Interpret the stepper motor from other motor
3. Distinguish switched reluctance motor from synchronous reluctance motor
4. Analyze square wave and sine wave permanent magnet brushless motor drives.
5. Develop the linear motor from conventional motor
6. Appraise the advanced synchronous motor
7. Select the appropriate drive for the specific purpose.
8. Design a component or a product applying all the relevant standards with realistic constraints

Module:1	**Stepper Motors:**	**4 hours**

Constructional and Working – Modes of excitation – Drive circuits – Control Aspects - Concept of lead angle.

Module:2	**Switched Reluctance Motors:**	**4 hours**

Constructional and Working – Power Converters and their controllers – Methods of rotor position sensing.

Module:3	**Synchronous Reluctance Motors:**	**5 hours**

Constructional and Working Significance of direct and quadrature inductances - Phasor diagram.

Module:4	**Permanent Magnet Brushless DC Motors**:	**5 hours**

Permanent Magnet materials – Magnet Characteristics – Permeance coefficient. Magnetic circuit analysis of PMBLDC – EMF and torque equations – Commutation – Power Converter and their controllers.

Module:5	**Permanent Magnet Synchronous Motors:**	**4 hours**

Principle of operation –EMF and Torque equations–Synchronous Reactance – Phasor diagram – Converter Volt-ampere requirements.

Module:6	**Advanced Synchronous Machines:**	**4 hours**

Flux Switching and Flux Reversal Machines - Claw Pole Alternators - Axial flux Machines - Construction and Working - Characteristics - Applications.

Module:7	**Linear Motors**:	**4 hours**

Linear DC Motors - Linear Induction Motors - Linear Synchronous Motors - Linear Switched

Reluctance Motors - Construction and Working - Applications.			
Module:8	**Contemporary issues:**		**2 hours**
		Total Lecture hours:	**30 hours**
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
List of Projects			
1. Execution of B-H Loop and demagnetization characteristics of BLDC motor			
2. Performance test of Hall sensors			
3. Open circuit test on permanent magnet DC motor			
4. Design of controllers for permanent magnet DC motor			
5. Execution of torque speed characteristics for permanent magnet DC motor			
6. Design controllers for square wave permanent DC motor			
7. Draw the phasor diagram, torque-speed characteristics sine wave DC motor.			
8. Perform test on permanent DC motor and draw Circle diagram for the same			
9. Design controllers for sine wave permanent DC motor.			
10. Study and construction of Switched Reluctance Motor in real time applications			
11. Execute simulation test and draw characteristics on stepper motor.			
12. Perform suitable test and obtain various characteristics of switched reluctance motor.			
13. Draw and simulate power circuit for linear induction motor			
14. Perform a suitable test on induction motor and draw various characteristics of same machine			
15. By performing suitable test estimate the efficiency of induction generator.			
Text Book(s)			
1.	T.J.E Miller, "Brushless Permanent Magnet and Reluctance Motor Drives", Clarendon Press, Oxford 1989.		
2.	R. Krishnan, "Permanent Magnet and Brushless DC Motors Drives", CRC Press, New York, 2010.		
Reference Books			
1.	T. Kenjo and S. Nagamori, "Permanent Magnet and Brushless DC Motor", Clarendon Press, London 1988.		
2.	T. Kenjo, "Stepper Motors and their Microprocessor Controls" , Clarendon Press, London.		
3.	Ion Boldea, "Linear Electric Machines, Drives and MAGLEVs Handbook", CRC Press, London, 2013.		
4.	P. P. Aearnely, "A Guide to Motor Theory and Practice Stepper Motors", Peter Perengrinus, London, 1982.		
5.	T. Kenjo and S. Nagamori, "Permanent Magnet and Brushless DC Motor", Clarendon Press, London 1988.		
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