DEPARTMENT OF

ELECTRICAL AND ELECTRONICS ENGINEERING

Syllabus and Scheme of Examination

M.Tech. in Power Electronics

2017-18

Institution

Vision - Pursuing Excellence, Empowering people, Partnering in Community Development.

Mission - To develop NMAM Institute of Technology, Nitte, as Center of Excellence by imparting Quality Education to generate Competent, Skilled and Humane Manpower to face emerging Scientific, Technological, Managerial and Social Challenges with Credibility, Integrity, Ethics and Social Concern.

Department:

Vision Statement:

Pursuing excellence in Electrical & Electronics Engineering, creating a research environment to promote innovation and address global challenges

Mission Statement:

- To equip students to face global challenges by excelling in professional career and higher education.
- To offer high quality graduate and post graduate programs in electrical & electronics engineering.
- To promote excellence in research, collaborative activities and contribute to social development with ethical values.

Programme Educational Objectives (PEO)

PEO1: Excel in professional career in industry, academia and entrepreneurial ventures by applying the knowledge of power electronics.

PEO2: Engage in designing power electronics systems and contribute in multidisciplinary engineering projects.

PEO3: Inculcate and exhibit ethical values, communication skills and adapt to current trends by engaging in research by providing supportive and leadership roles.

Programme Outcomes (PO)

At the end of M.Tech (Power Electronics) program the students will have an ability to

PO1: Acquire and apply knowledge of power electronics in a technologically changing scenario.

PO2: Apply critical and innovative ideas to analyze problem pertaining to power electronic and take up research independently.

PO3: Obtain optimal power electronic solutions for electrical engineering problems keeping in view of social concerns.

PO4: Conduct literature survey, apply appropriate tool to solve power electronic problems, conduct experiments and interpret data, for the development of technological knowledge.

PO5: Use modern tools to simulate and model power electronics systems and carry out performance evaluation.

PO6: Function effectively to manage the work as an individual and in a team.

PO7: Demonstrate managerial and financial skills.

PO8: Communicate effectively with engineering fraternity and society, write effective reports and design documentation.

PO9: Engage in lifelong learning with a commitment to improve knowledge in a technologically changing scenario.

PO10: Appreciate and Practice professional ethics for sustainable development of society.

PO11: Self-learn and take corrective measures independently to address mistakes.

NMAM INSTITUTE OF TECHNOLOGY, NITTE
SCHEME OF TEACHING AND EXAMINATION FOR M. TECH. POWER ELECTRONICS
(AUTONOMOUS SCHEME)

Revised at the BOS meeting on 20th May 2017

I SEMESTER

Sub. Code	Name of the Subject	Contact hours/week	Duration of Sem. End Exam in hours	Marks for		Total Credits
		L/T/P/S		CIE	SEE	
17EPE101	Power Semiconductor Devices	4/0/2/0	03	50	50	5
17EPE102	Solid State Power Controllers	4/0/2/0	03	50	50	5
17EPE103	Switched Mode Power Supply	4/0/2/0	03	50	50	5
17EPE11X	Elective - I	4/0/0/0	3	50	50	4
17EPE12X	Elective -II	4/0/0/0	3	50	50	4
17EPE104	Research Experience through Practice-I	0/0/4/0	-	100	-	2
TOTAL			15	350	250	25

ELECTIVE –I		ELECTIVE-II	
17EPE111	Embedded System Design	17EPE121	Advanced Digital Signal Processing
17EPE112	Soft Computing	17EPE122	Advanced Control Systems
17EPE113	Applied Mathematics	17EPE123	Special Electrical Machines and Control
17EPE114	MPPT in Solar Systems	17EPE124	Modeling and Analysis of Electrical Machines

M. TECH. POWER ELECTRONICS
(AUTONOMOUS SCHEME)
Ii SEMESTER

Sub. Code	Name of the Subject	Contact hours/week	Duration of Sem. End Exam in hours	Marks for		Total Credits
		L/T/P/S		CIE	SEE	
17EPE201	AC and DC Drives	4/0/2/0	3	50	50	5
17EPE202	Modeling and Simulation of Power Electronic Systems	4/0/2/0	3	50	50	5
17EPE203	Application of Power Electronics to HVDC and FACTS	4/0/2/0	3	50	50	5
17EPE21x	Elective - III	4/0/0/0	3	50	50	4
17EPE22x	Elective -IV	4/0/0/0	3	50	50	4
17EPE204	Research Experience through Practice-II	0/0/4/0	0	100	--	2
TOTAL			15	350	250	25

ELECTIVE –III		ELECTIVE-IV	
17EPE211	Power Quality Enhancement using Custom Power Devices	17EPE221	PWM Controlled Power Electronics Converters
17EPE212	Multi-Terminal DC Grids	17EPE222	Converters for Solar and Wind Power Systems
17EPE213	Smart Grid	17EPE223	DSP Application to Drives
17EPE214	Hybrid Electric Vehicles	17EPE224	Multilevel Converters for Industrial Applications

List of Audit courses currently offered: 17AP006: LabVIEW Basics

M. TECH. POWER ELECTRONICS
(AUTONOMOUS SCHEME)
III SEMESTER

Revised at the BOS meeting on **20th May 2017**

Sub. Code	Name of the Subject	Duration Practical Field work	Marks for		Total Credits
			CIE	SEE	
17EPE301	Industrial Training / Mini-Project	Full time 8 weeks	50 (report) + 50 (presentation)	--	8
17EPE302	Seminar on special topics	----	100	--	2
17EPE302	Project-Part I	Full time 10 weeks	100 (report) + 100(presentation)	--	10
TOTAL			400		20

M. TECH. POWER ELECTRONICS
(AUTONOMOUS SCHEME)
IV SEMESTER

Sub. Code	Name of the Subject	Duration Practical Field work	Marks for		Total Credits
			CIE	SEE	
17EPE401	Project -Part II	Full time 20 weeks	200 [PPE*-I – 100 PPE-II – 100]	200	30
TOTAL			400		30
GRAND TOTAL From 1st to 4th semester: 100 credits (2000 marks)					

PPE – Project Progress Evaluation

DETAILED COURSE CONTENTS

Power Semiconductor Devices

Course Code	: **17EPE101**	Credits	: 05
Contact Hours	: 4-0-2-0	CIE Marks	: 50
Total Lecture Hours	: 52	SEE Marks	: 50

Course objectives

1. To identify various power semiconductor devices and their ratings for various power electronic application.
2. To understand the static and dynamic characteristics of voltage and current controlled power semiconductor devices
3. To enable the students, the knowledge of selection of devices for different power electronics applications
4. To understand the control and Gate Drive requirements for different power devices.

Unit - I

Power Diodes: on-state losses, switching characteristics-turn-on transient, turn-off transient and reverse recovery transient, Schottky diodes, snubber requirements for diodes, diode snubber.

Power BJT'S: on state losses, switching characteristics, resistive switching specifications, clamped inductive switching specifications, turn-on transient, turn-off transient, storage time, base drive requirements, switching losses, device protection- snubber requirements for BJT'S and snubber design - switching aids.

Thyristors:- switching characteristics, turn-on transient and di/dt limitations, turnoff transient, turn-off time and reapplied dv/dt limitations, gate drive requirements, ratings of thyristors, snubber requirements and snubber design. **12 Hours**

Unit - II

TRIACs: Basic structure and operation-I characteristics, ratings, snubber requirements**.**

Gate Turnoff Thyristor (GTO): Basic structure and operation, GTO switching characteristics, GTO turn-on transient, GTO turn -off transient, minimum on and off state times, gate drive requiremen**ts,** maximum controllable anode current, overcurrent protection of GTO'S.

10 Hours

Unit - III

Power MOSFET'S:- Basic structure, V-I characteristics, turn-on process, on state operation, turn-off process, switching characteristics, resistive switching specifications, clamped inductive switching specifications - turn-on transient and di/dt limitations, turn-off transient, turn off time, switching losses, effect of reverse recovery transients on switching stresses and losses - dv/dt limitations, gating requirements, gate charge - ratings of MOSFET'S, FBSOA and RBSOA curves, device protection –snubber requirements, MOSFET drivers and protection, Miller region. **10 Hours**

Unit - IV

Insulated Gate Bipolar Transistors (IGBT'S): Basic structure and operation, latch up IGBT, switching characteristics, resistive switching specifications, clamped inductive switching specifications - IGBT turn-on transient, IGBT turn off transient- current tailing - gating requirements -ratings of IGBT'S, FBSOA and RBSOA curves, switching losses - minimum on and off state times - switching frequency capability – over current protection of IGBT'S, short circuit protection, snubber requirements and snubber design. IGBT drivers and protection, Active clamping. **10 Hours**

Unit - V

New Power Semiconductor Devices: MOS gated thyristors, MOS controlled thyristors or MOS GTO'S, base resistance controlled thyristors, emitter switched thyristor, GaN and SiC devices. Introduction to wide band gap devices.

Thermal design of power electronic equipment, heat transfer by conduction, transient thermal impedance - heat sinks, heat transfer by radiation and convection - heat sink selection for power semiconductor devices. **10 Hours**

Suggested List of Laboratory Exercises:

Note: Suggested to use OrCAD PSpice, MATLAB / SIMULINK, PSIM Software for the simulation of experiments listed below.

1. Modeling and simulation of power diodes, power BJT'S, thyristors.
2. Modeling and simulation of TRIAC, GTO'S.
3. Modeling and simulation of Power MOSFET'S.
4. Modeling and simulation of Power IGBT.
5. Modeling and simulation of thermal design for power electronic equipment

Course Outcomes

At the end of the course student will be able to

1. Comprehend the types, characteristics, protection and modeling of Power Diodes, Power BJT's and Thyristors.
2. Analyze the structure, characteristics, gate drive requirements and modeling of GTO's and TRIACS.
3. Explain the principle of operation of MOSFET with their characteristics and effect of reverse recovery transients on switching stresses & losses
4. Explain the principle of operation of IGBT with their characteristics and protection against over-current & short-circuit.
5. Illustrate the construction and features of the emerging power electronic devices

Reference Books

1. Ned Mohan, Tore M. Undeland, William P. Robbins, "Power Electronics Converters, Applications, and Design", 3rdEdition. Wiley India Pvt Ltd, 2011.
2. G. Massobrio, P. Antognetti, "Semiconductor Device Modeling with Spice", McGraw-Hill, 2nd Edition, 2010.
3. B. Jayant Baliga, "Power Semiconductor Devices", 1st Edition, International Thompson Computer Press, 1995.
4. V. Benda, J. Gowar, and D. A. Grant, "Discrete and Integrated Power Semiconductor Devices: Theory and Applications", John Wiley & Sons, 1999.
5. Joseph Vaithiyathil, "Power Electronics Principles and Applications" Mc Graw Hill Education,2010.

Solid State Power Controllers

Course Code	: **17EPE102**	Credits	: 05
Contact Hours	: 4-0-2-0	CIE Marks	: 50
Total Lecture Hours	: 52	SEE Marks	: 50

Course objectives

1. To provide the electrical circuit concepts behind the different working modes of power converters so as to enable deep understanding of their operation.
2. To equip with required skills to derive the criteria for the design of power converters starting from basic fundamentals.
3. To analyse and comprehend the various operating modes of different configurations of power converters.

Unit - I

Line Commutated Converters: Phase control, single phase semi-converter & fully controlled converter, three phase semi controlled & fully controlled converter, dual converters, power factor improvement methods, effect of source inductance, single phase series converters, twelve pulse converter and design of converter circuits. **12 Hours**

Unit - II

Inverters: Principle of operation, performance parameters, single phase bridge inverters and three phase inverters. **09 Hours**

Unit - III

Voltage Control of Single Phase Inverters: Single/multiple, pulse/SPWM/ modified SPWM methods, voltage control of three phase inverter, SPWM/third harmonic PWM/Space vector modulation, harmonic reduction, current source inverter, comparison between VSI & CSI. **12 Hours**

Unit - IV

Multilevel Inverters: Introduction, types, diode clamped multi-level inverters, features & applications. Introduction to H5 topology, Heric Topology and Neutral Point Clamped Inverter. **09 Hours**

Unit - V

DC-DC Chopper: Principle of operation, analysis of step-down and step-up chopper, classification of chopper, chopper circuit design. **10 Hours**

Suggested List of Laboratory Exercises:

Note: Suggested to use OrCAD PSpice, MATLAB / SIMULINK, PSIM Software for the simulation of experiments listed below.

1. Performance analysis of single phase semi-controlled converter for RL loads for continuous mode and study the effect of source inductance.
2. Performance analysis of single phase fully-controlled converter for RL loads for continuous current mode and study the effect of source inductance.
3. Performance analysis of single phase fully-controlled converter for RL load for discontinuous current mode and study the effect of source inductance
4. Performance analysis of three phase fully controlled converter for RL load for continuous current and discontinuous current mode.
5. Performance analysis of three phase semi-controlled converter for RL loads for continuous current and discontinuous current mode.

Course Outcome:

Students completing **Solid State Power Controllers** course will be able to:

1. Acquire and apply knowledge of working of line commutated converters and their design
2. Analyze the performance parameters of power inverters.

3. Illustrate various PWM techniques applicable with a voltage controlled single phase inverter
4. Model, analyze and understand concept of multilevel inverters.
5. Analyze and design various DC-DC chopper circuits.

Reference Books

1. Rashid M.H, "Power Electronics: Circuits Devices and Applications",3rd Edition, Pearson,2011.
2. B. K. Bose, "Modern Power Electronics & AC Drives", PHI,2012.
3. Ned Mohan, Tore M. Undeland, William P. Robbins, "Power Electronics Converters, Applications, and Design", 3rdEdition,Wiley India Pvt Ltd, 2011

Switched Mode Power Supply

Course Code	: **17EPE103**	Credits	: 05
Contact Hours	: 4-0-2-0	CIE Marks	: 50
Total Contact Hours	: 52	SEE Marks	: 50

Course objectives

To introduce numerical methods for the solution

1. To understand the advantages of Switched mode Power supply over linear power supplies
2. To understand the working and design various switched mode DC-DC converters under continuous and discontinuous current mode.
3. To evaluate the need of derived / isolated converters and study the working and design of various types of derived converters.
4. To introduced concepts of Zero voltage and Zero current switching and to understand the use of resonant converters to implement the ZVS and ZCS concepts.
5. To introduce various control schemes to design SMPS and understand the procedure to be followed in design of magnetic components.

Unit - I

DC – DC Converters (Basic Converters): Linear voltage regulators (LVRs), a basic switching converter(SMPC), comparison between LVR & SMPC, principle of operation and analysis of buck converter analysis, inductor current ripple and output voltage ripple, capacitor resistance effect, Design of inductor and transformers for SMPC. synchronous rectification, design considerations, buck converter for discontinuous current operation, principle of operation and analysis of boost converter, inductor current ripple and output voltage ripple, inductor resistance effect, design considerations, boost converter for discontinuous current operation. **12 Hours**

Unit - II

Derived Converters: Principle of operation and analysis of buck-boost converter analysis, inductors current ripple and output voltage ripple, design considerations, buck-boost converter for continuous and discontinuous current operation, principle of operation and analysis of CUK converter, inductor current ripple and output voltage ripple, capacitor resistance effect, design considerations, Single Ended Primary Inductance Converter (SEPIC). **10 Hours**

Unit - III

Isolated Converters: Introduction, transformer models, principle of operation and analysis of fly back converter-continuous and discontinuous current mode of operation, design considerations, principle of operation and analysis of forward converter, design considerations, double ended (Two switch) forward converter, principle of operation and analysis of push-pull converter, design considerations, principle of operation and analysis of full bridge and half-bridge DC-DC converters, design considerations, current fed converters, multiple outputs.

10 Hours

Unit - IV

Resonant Converters: Introduction, resonant switch ZCS converter, principle of operation and analysis, resonant switch ZVS converter, principle of operation and analysis, series resonant inverter, series resonant DC-DC converter, parallel resonant DC-DC converter, series- parallel resonant DC-DC converter, resonant converters comparison, resonant DC link converter.

10 Hours

Unit - V

Control of DC-DC Converter: Modeling of DC-DC converters, power supply control, Voltage Mode Control, control loop stability, small signal analysis, switch transfer function, filter transfer function, PWM transfer function, Type-2 error amplifier with compensation, design, simulation of feedback control, Type-3 error amplifier with compensation, design. **10 Hours**

Suggested List of Laboratory Exercises:

Note: Suggested to use OrCAD PSpice, MATLAB / SIMULINK, PSIM Software for the simulation of experiments listed below.

1. Modeling and Simulation of Buck, Boost
2. Simulation of Buck Boost Converter
3. Design of Inductor and Selection of Capacitor
4. Simulation of Cuk, SEPIC Converter
5. Study and verification of different gating pulse generating circuits
6. Design and implementation of any one switched mode converter and verification of the results.

Course Outcome:

Students completing **Switched Mode Power Supply** course will be able to:

1. Illustrate the basic DC – DC Converters like buck, boost converters and design the same.
2. Analyze and design the buck-boost, Cuk and SEPIC converters for the given design specifications.
3. Model the Derived DC-DC isolated Converters, analyze its working and design for the given specification.
4. Analyze the working principle of resonant converters and understand the importance of Zero voltage and Zero current switching
5. Illustrate the need for Control and Compensating network for SMPS and design high frequency inductor and transformers to be used with SMPS.

Reference Books

1. Daniel W Hart, "Power Electronics", Tata McGraw Hill, 2011.
2. Robert W. Erickson, Dragan Maksimovic, "Fundamentals of Power Electronics", Springer; 2nd ed. 2001.
3. Ned Mohan, Tore M. Undeland, William P. Robbins, "Power Electronics Converters, Applications, and Design", 3rd Edition, Wiley India Pvt Ltd, 2010.
4. Umanand L " Power Electronics- Essentials and Applications", Wiley 2011
5. Christophe P. Basso, "Switch-Mode Power Supplies Spice Simulations and Practical Designs" BPB Publication, 2010.
6. Dr. Raymond B. Ridley, "Power Supply Design, Volume 1: Control" Ridley Designs, 2012
7. Umanand L and Bhatt S R, "Design of Magnetic Components for Switched Mode Power Converters", New Age International, New Delhi, 2001

Research Experience through Practice-I

Course Code	: **17EPE104**	Credits	: 02
Contact Hours	: 0-0-4-0	CIE Marks	: 100
Total Contact Hours	: 52	SEE Marks	: -

Individual PG Students are to be allotted to the individual faculty members based on student's area of research interest, specialization of faculty members in the beginning of the first semester.

Module - 1

Defining the research problem - Selecting the problem - Necessity of defining the problem - Techniques involved in defining the problem - Importance of literature review in defining a problem - Survey of literature - Primary and secondary sources - Reviews, treatise, monographs patents - web as a source - searching the web - Identifying gap areas from literature review - Development of working hypothesis, systematic way of conducting research, write a review / research paper, research proposal, preparation of research report.

Module -2

- Introduction various simulation tools related to power electronics
- Use of software tools (MATLAB-Simulink , OrCAD , PSIM)
- Introduction to typesetting tool (Latex).
- At the end of the course students should submit a research protocol and should present the idea.

Embedded System Design

Course Code	: **17EPE111**	Credits	: 04
Contact Hours	: 4-0-0-0	CIE Marks	: 50
Total Contact Hours	: 50	SEE Marks	: 50

Course objectives

1. To introduce the fundamental concepts of Embedded System design
2. To get insight of general purpose, single purpose and application specific instruction set processors.
3. To understand the importance of Memory and IO devices and their interfacing.
4. To introduce concept of Real Time Operating Systems.

Unit - I

Embedded systems overview, Design challenge – optimizing design metrics Technologies - Processor technologies, IC technologies, Design technologies

Custom Single Purpose Processor design: Combinational, Sequential, RT Level designs, Optimizing,

General Purpose Processor: Software Development Environment, GPP Design. **10 Hours**

Unit - II

Application Specific Instruction Set Processor: Introduction to 8051, Architectural features, Instruction list and basic programming,

Introduction to DSP, Architecture and features of any TMS processor. **10 Hours**

Unit - III

Standard Single Purpose Processor: Peripherals – Timers, Counters, WDT, UART, PWM, LCD, Keypad, Stepper Motor Controllers, ADC, DAC, RTC

Memory: ROM & RAM and their variants Composing Memory, Memory Hierarchy and Cache, Advanced RAM, Memory Management Unit. **10 Hours**

Unit - IV

Interfacing: Communication basic, Interfacing method, Interrupts, DMA, Arbitration, Multi Bus Architecture

Advanced Communication Principles Various Serial, Parallel, Wireless Protocols

Microprocessor Interfacing: Shared data problem, Interrupt Latency. **10 Hours**

Unit - V

RTOS: Software Architecture Review, Introduction to RTOS, Task, States, Data, Semaphore

RTOS Services: Mailboxes, Queues, Pipes, Timer Functions, Events, Memory Management

RTOS Example: Review of one RTOS

ARM: Architecture and features of ARM processor, Modes of operation of ARM 7TDMI.

10 Hours

Course Outcome:

Students completing **Embedded System Design** course will be able to:

1. Explain the overview of embedded system and associated technologies
2. Illustrate the various processing element in an embedded system
3. Appreciate the necessity of memory devices which can be used with the embedded system
4. Illustrate the concepts of interfacing and the type of devices that can be interfaced.
5. Appreciate the importance of RTOS and understand some generally used embedded systems.

Reference Books

1. Frank Vahid and Tony Givargis, “Embedded system design: A unified hardware/ Software introduction”, Third edition, John Wiley & sons, 2010
2. David E. Simon, “An Embedded Software Primer”, Addison Wesley; Paper Back edition, 1999.
3. Raj Kamal, “Embedded System” 2nd Edition, Tata McGraw-Hill Education
4. Santanu chattopadhyay, “Embedded system Design”, PHI Learning Pvt. Ltd., 2010

Soft Computing

Course Code	: **17EPE112**	Credits	: 04
Contact Hours	: 4-0-0-0	CIE Marks	: 50
Total Contact Hours	: 52	SEE Marks	: 50

Course objectives

1. To introduce the soft computing concepts and distinguish conventional and soft computing
2. To understand ANN concepts their structure and applications.
3. To study fuzzy logic concepts and their applications
4. To understand Genetic Algorithms and their applications

Unit - I

Soft Computing: Introduction, difference between conventional and soft computing, main components of soft computing: history and basic principles

Artificial neural network: structure of neuron**,** neural network architectures, examples

Single layer networks: Perceptron, Adaptive linear neuron (Adaline), and the LMS algorithm.

11 Hours

Unit - II

Associative Memory Networks: Training algorithm for pattern association, Auto, Hetero, Bidirectional Associative Network, Hopfield Network, Interactive Auto associative, Temporal Associative Network. **05 Hours**

Multilayer and unsupervised networks: Error back propagation algorithm, winner-take-all networks, Learning vector quantizing, counter propagation networks, adaptive resonance theorem Application of Generalized neuron models. **05 Hours**

Unit - III

Fuzzy logic: Fuzzy sets, Properties of fuzzy sets, operation in fuzzy sets, fuzzy relations, the extension principle, Linguistic variables, Fuzzy proportions, Fuzzy if then statements, inference rules, compositional rule of inference. **11 Hours**

Unit - IV

Fuzzy Systems: Fuzzification and defuzzification procedures, applications of fuzzy logic : washing machine, traffic light controllers, steady and transient DC machine model, fuzzy power system stabilizers. **10 Hours**

Unit - V

Genetic Algorithm: Simple genetic Algorithms, improved genetic algorithms, limitations of GA, application. **Introduction to Swarm Intelligence Technology.** **10 Hours**

Course Outcome:

Students completing **Soft Computing** course will be able to:

1. Analyze the basic concepts in Soft computing and understand the basics of single layer neural network
2. Illustrate various types of associative memory and unsupervised neural network
3. Illustrate the mathematical aspects and methods of fuzzy logic control.
4. Apply fuzzification, defuzzification methods and Analyze various applications of fuzzy logic control.
5. Appreciate the concepts of genetic algorithms and its applications

Reference Books

1. Devendra K. Chaturvedi . "Soft Computing: Techniques and its Applications in Electrical Engineering" Springer Publications, 2008.
2. Timoty Ross, "Fuzzy Logic with engineering applications", McGraw Hill
3. Kishan Mehrotra, C. K. Mohan, Sanjay Ranka , "Elements of Artificial Neural Networks", Penram,2010.
4. S.N Sivanandam, S.N Deepa, "Principles of Soft Computing", Wiley India , 2007
5. S. Rajsekaran & G.A. Vijayalakshmi Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithm: Synthesis and Applications" Prentice Hall of India.

Applied Mathematics

Course Code	: **17EPE113**	Credits	: 04
Contact Hours	: 4-0-0-0	CIE Marks	: 50
Total Contact Hours	: 52	SEE Marks	: 50

Teaching Department: Mathematics

Course objectives

1. To introduce numerical methods for the solution of algebraic and transcendental
2. To understand various techniques to get Numerical Solution of Partial Differential Equations
3. To solve the problems pertaining to linear algebra, system of linear algebraic equations and Eigen value
4. To introduce linear programming technique for optimizing the solution and solve problems pertaining to graph theory.

Unit - I

Numerical Methods: Solution of algebraic and transcendental equations iterative methods based on second degree equation – Muller method (no derivation) Chebyshev method, general iteration method (first order), acceleration of convergence, system of non-linear equations and complex roots – Newton-Raphson method, polynomial equations – Birge - Vieta method and Bairstow's method. **10 Hours**

Unit - II

Numerical Solution of Partial Differential Equations: Classification of second order equations, parabolic equations- solution of one dimensional heat equation, explicit method, Crank-Nicolson method and Du Fort-Frankel method, hyperbolic equations- solution of one dimensional wave equation.

Numerical solution of differential equations – Numerov method. **10 Hours**

Unit - III

Linear Algebra: Vector spaces, linear dependence, independence, basis and dimension, elementary properties.

System of Linear Algebraic Equations and Eigen Value Problems: Iterative methods - Gauss-Seidal method, SOR method, Eigen value problems – Gerschgorian circle, Eigen values and Eigen vectors of real symmetric matrices -Jacobi method, Givens method. Conditions/Tests for-positive definite, semi-definite and indefinite Matrices and comment on stability **11 Hours**

Unit - IV

Optimization: Linear programming- formulation of the problem, graphical method, general linear programming problem, simplex method, artificial variable technique -M-method.

Graph Theory: Basic terminologies, types of graphs, sub graphs, graphs isomorphism, connected graphs-walks, paths, circuits, connected and disconnected graphs, operations on graphs, Eulerian paths and circuits, Hamiltonian paths and circuits, applications of graphs.

11 Hours

Unit - V

Interpolation: Hermit interpolation, spline interpolation.

Linear Transformations: Definition, properties, range and null space, rank and nullity, algebra of linear transformations- invertible, singular and nonsingular transformations, representation of transformations by matrices. **10 Hours**

Course Outcomes

At the end of the course student will be able to

1. Apply numerical methods for the solution of algebraic and transcendental
2. Use various techniques to get Numerical Solution of Partial Differential Equations
3. Analyze the problems pertaining to linear algebra and solve system of linear algebraic equations and Eigen value problems

4. Apply linear programming technique for optimizing the solution and analyze problems pertaining to graph theory
5. Comprehend interpolation problems and apply linear transformations techniques.

Reference Books

1. M K Jain, S R K Iyengar and R K Jain, “Numerical Methods for Scientific and Engineering Computations”, New Age International, 2004.
2. M K Jain, “Numerical Solution of Differential Equations”, 2nd Edition, New Age International, 2008.
3. Dr. B.S. Grewal, “Numerical Methods in Engineering and Science”, Khanna Publishers, 1999.
4. Dr. B.S. Grewal, “Higher Engineering Mathematics”, 41st Edition, Khanna Publishers, 2011.
5. Narsingh Deo, “Graph Theory with Applications to Engineering and Computer Science”, PHI, 2012.
6. Kenneth Hoffman and Ray Kunze, “Linear Algebra”, 2nd Edition, PHI, 2011.

MPPT in Solar Systems

Course Code	: **17EPE114**	Credits	: 04
Contact Hours	: 4-0-0-0	CIE Marks	: 50
Total Contact Hours	: 52	SEE Marks	: 50

Course objectives:

- To explain the PV cell, its characteristics and its models, equivalent circuits and circuit parameter calculations.
- To explain different methods of tracking maximum power point and effect of noise on MPPT and reduction of noise.
- To explain distributed Maximum Power Point Tracking of PV arrays and its analysis.
- To explain the design of high energy efficiency power converters for PV MPPT.

Unit-I

PV Modeling: From the Photovoltaic Cell to the Field, The Electrical Characteristic of a PV Module, The Double-Diode and Single-Diode Models, From Data Sheet Values to Model Parameters, Example: PV Module Equivalent Circuit Parameters Calculation, The Lambert W Function for Modeling a PV Field, Example.

Maximum Power Point Tracking: The Dynamic Optimization Problem, Fractional Open-Circuit Voltage and Short-Circuit Current, Soft Computing Methods, The Perturb and Observe Approach. **10 Hours**

Unit-II

Maximum Power Point Tracking (continued): Improvements of the P&O Algorithm, Evolution of the Perturb Method, PV MPPT via Output Parameters, MPPT Efficiency.

Noise Sources and Methods for Reducing their Effects: Low-Frequency Disturbances in Single-Phase Applications, Instability of the Current-Based MPPT Algorithms, Sliding Mode in PV System, Analysis of the MPPT Performances in a Noisy Environment, Numerical Example. **11 Hours**

Unit-III

Distributed Maximum Power Point Tracking of Photovoltaic Arrays: Limitations of Standard MPPT, A New Approach: Distributed MPPT, DC Analysis of a PV Array with DMPPT, Optimal Operating Range of the DC Inverter Input Voltage. **10 Hours**

Unit-IV

Distributed Maximum Power Point Tracking of Photovoltaic Arrays (continued): AC Analysis of a PV Array with DMPPT. **09 Hours**

Unit-V

Design of High-Energy-Efficiency Power Converters for PV MPPT Applications: Introduction, Power, Energy, Efficiency, Energy Harvesting in PV Plant Using DMPPT Power Converters, Losses in Power Converters, Losses in the Synchronous FET Switching Cells, Conduction Losses, Switching Losses. **11 Hours**

Course outcomes:

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

- Explain the PV cell, its characteristics and its models, equivalent circuits and circuit parameter calculations.
- Explain different methods of tracking maximum power point.
- Explain the sources of noise, effect of noise on MPPT and reduction of noise.
- Explain Distributed Maximum Power Point Tracking of PV arrays.
- Conduct DC and AC analysis of PV array with DMPPT.
- Explain the use of high energy efficiency power converters for PV MPPT application.

Text Book

1. Power electronics and Control Techniques for Maximum energy harvesting in Photovoltaic systems Nicola Femia et al, CRC Press, 2013

Advanced Digital Signal Processing

Course Code	: **17EPE121**	Credits	: 04
Contact Hours	: 4-0-0-0	CIE Marks	: 50
Total Contact Hours	: 52	SEE Marks	: 50

Course objectives

1. To study the parametric methods for power spectrum estimation.
2. To study adaptive filtering techniques using LMS algorithm and to study the applications of adaptive filtering.
3. To study multi-rate signal processing fundamentals.
4. To study the analysis of speech signals.
5. To introduce the student to wavelet transforms.

Unit – I

PARAMETRIC METHODS FOR POWER SPECTRUM ESTIMATION

Relationship between the auto correlation and the model parameters – The Yule – Walker method for the AR Model Parameters – The Burg Method for the AR Model parameters – unconstrained least-squares method for the AR Model parameters – sequential estimation methods for the AR Model parameters – selection of AR Model order. **11 Hours**

Unit – II

ADAPTIVE SIGNAL PROCESSING

FIR adaptive filters – steepest descent adaptive filter – LMS algorithm – convergence of LMS algorithms – Application: noise cancellation – channel equalization – adaptive recursive filters – recursive least squares. **10 Hours**

Unit – III

MULTIRATE SIGNAL PROCESSING

Decimation by a factor D – Interpolation by a factor I – Filter Design and implementation for sampling rate conversion: Direct form FIR filter structures – Polyphase filter structure.

10 Hours

Unit – IV

SPEECH SIGNAL PROCESSING

Digital models for speech signal : Mechanism of speech production – model for vocal tract, radiation and excitation – complete model – time domain processing of speech signal:- Pitch period estimation – using autocorrelation function – Linear predictive Coding: Basic Principles – autocorrelation method – Durbin recursive solution. **10 Hours**

Unit – V

WAVELET TRANSFORMS

Fourier Transform : Its power and Limitations – Short Time Fourier Transform – The Gabor Transform – Discrete Time Fourier Transform and filter banks – Continuous Wavelet Transform – Wavelet Transform Ideal Case – Perfect Reconstruction Filter Banks and wavelets – Recursive multi-resolution decomposition – Haar Wavelet – Daubechies Wavelet. **11 Hours**

Course Outcome:

Students completing **Advanced Digital Signal Processing** course will be able to:

1. Explain the parametric methods for power spectrum estimation.
2. Illustrate the adaptive filtering techniques using LMS algorithm and to study the applications of adaptive filtering.
3. Explain multirate signal processing fundamentals.
4. Perform the analysis of speech signals.
5. Introduce the concept of wavelet transforms.

Reference Books

1. John G.Proakis, Dimitris G.Manobakis, Digital Signal Processing, Principles, Algorithms and Applications, 4th edition, (2007) PHI.
2. Monson H.Hayes – Statistical Digital Signal Processing and Modeling, Wiley, 2008.

3. Vaidyanathan P "Multirate Signal Processing" PHI,
4. L.R.Rabiner and R.W.Schaber, Digital Processing of Speech Signals, 1st Edition, Pearson India 2003.
5. Roberto Crist, Modern Digital Signal Processing, Thomson Brooks/Cole (2004)
6. Raghuveer. M. Rao, Ajit S.Bopardikar, Wavelet Transforms, Introduction to Theory and applications, Pearson Education, Asia, 2000.

Advanced Control Systems

Course Code	: **17EPE122**	Credits	: 04
Contact Hours	: 4-0-0-0	CIE Marks	: 50
Total Contact Hours	: 52	SEE Marks	: 50

Course objectives

1. To introduce concept of digital control systems and pulse transfer function
2. To apply stability analysis on continuous and discrete time systems.
3. To illustrate the role of controllability and observability.
4. To educate on modal concepts and design of state and output feedback controllers and estimators.

Unit - I

Digital Control Systems (R1): Review of Z- Transform and its properties.
Inverse Z - transforms, Z - transforms for solving difference equation, impulse sampling and data hold, obtaining z-transform by the convolution integral method, reconstructing original signal from sampled signals, Pulse transfer function, realization of digital controllers and digital filters. **10 Hours**

Unit - II

Continuous and Discrete time Systems (R1 &R2):: Mapping between the s-plane and z-plane, Stability analysis (Jury's Stability Test and Bilinear Transformation), State model for continuous time and discrete time systems, Solutions of state equations (for both continuous and discrete systems), pulse transfer function matrix, Discretization of continuous time state space equations. **11 Hours**

Unit - III

Design of Discrete time control system (R1): Transient and steady state response analysis, Design based on the root locus method, Design based on the frequency response method. **10 Hours**

Unit - IV

Modern Control Theory (R1 &R2): Concepts of controllability and observability (for both continuous and discrete systems), pole placement by state feedback (for both continuous and discrete systems), full order and reduced order observes (for both continuous and discrete systems), dead beat control by state feedback. **10 Hours**

Unit - V

Non Linear Control Systems (R3): Introduction, class of nonlinear systems: separable non-linearities, Filtered Nonlinear system. The describing function analysis, describing functions of common nonlinearities, stability analysis by describing function method, second order nonlinear system on the phase plane, fundamental types of phase portraits, system analysis on phase plane, Lyapunov's stability criterion for non-linear systems. **11 Hours**

Course Outcomes

At the end of the course student will be able to

1. Use the Z-transfer technique to analyze the system in discrete domain
2. Analyze the stability of a closed loop control system in discrete domain
3. Design the discrete time control system
4. analyse the controllability and observability of a system
5. Analyze the behavior of non-linear control system

Reference Books

1. Ogata. K, "Discrete Time Control Systems", Second Edition, PHI, 2011.
2. Ogata. K. "Modern Control Engineering", 5thEdition, PHI, 2010.
3. Gopal. M, "Digital Control and State Variable methods", TMH, 2011.
4. Kuo, "Digital Control Systems", 2nd Edition, Oxford University Press.
5. C. T Chen, "Analog and Digital Control System Design: Transfer-Function, State-Space, and Algebraic Methods" Oxford University Press; 1st edition, 2006

Special Electrical Machines and Control

Course Code	: **17EPE123**	Credits	: 04
Contact Hours	: 4-0-0	CIE Marks	: 50
Total Contact Hours	: 52	SEE Marks	: 50

Course objectives

1. To introduce new and advanced electrical machine like stepper motor, Switched Reluctance Motor, Synchronous Reluctance motor, Permanent Magnet DC (PMDC) Motor, Brushless Permanent Magnet DC (BLDC) Motors, Servo motors & linear electrical machine their modeling and control.

Unit – I

Stepper Motor: Variable reluctance (VR) Stepper Motor, Permanent Magnet Stepper Motor, Hybrid Stepper Motor, Other Types, Windings of Stepper Motor, open –loop, closed loop control of stepper motor, Microprocessor based control of stepper motor. **10 Hours**

Unit – II

Switched Reluctance Motor (SRM): Construction, Principle of working, Basic SRM analysis, constraints on pole arc and tooth arc, Power Converter Circuits, Control of SRM, Rotor Position sensors, Current Regulator, Microprocessor Based Control of SRM, Sensorless Control of SRM.

Synchronous Reluctance Motor (SyRM): Construction, Working, Control of SyRM, Advantage, Applications. **10 Hours**

Unit – III

PMDC and BLDC Motors: Permanent Magnet DC (PMDC)Motor – Construction, working, Types of PMDC Motors, Brushless Permanent Magnet DC (BLDC) Motors – Classification, construction, Electronic commutation, principle of operation, BLDC square wave motor, Types of BLDC motor, Control of BLDC motor, Microprocessor Based control, DSP Based Control, Sensorless Control, Comparison of DC and BLDC motor, Applications

Permanent Magnet Synchronous Motor: Construction, principle of operation, Control of PMSM, Applications of PMSM. **11 Hours**

Unit – IV

Single Phase Special Electrical Machines: AC Series Motor – Construction, Working Principle, torque-speed characteristics. Repulsive Motor – Construction, types. Hysteresis Motor, Single Phase Reluctance Motor, Universal Motor – Types, Construction, principle of operation, speed control.

Servo Motors: DC Servo Motors – Construction, Principle of operation, voltage equation, control of DC servo motor. AC Servo Motor – Construction, working, Analysis of two-phase AC servo motor, torque speed characteristics. **11 Hours**

Unit – V

Linear Electric Machines: Linear Induction Motor (LIM) – Construction, Thrust equation, performance equation, goodness factor, Certain design aspects, Control of LIM. Linear Synchronous Motor (LSM) – Types, construction, thrust equation, control, Application. DC Linear Motor (DCLM) – types, construction, thrust equation, persistent current tubular electromagnetic launcher, induction tubular EML, DC-pulsed flat series EML, DC tubular series EML. Linear Reluctance Motor (LRM) – Construction, working, operation with DC, operation with AC. Linear Levitation Machines (LLM) – Principle of Levitation, attractive type, repulsive type, Levitation Goodness factor and stiffness. **10 Hours**

Reference Books

1. E. G Janardanan, 'Special Electrical Machines' PHI Delhi, 2014.
2. T.J.E. Miller, 'Brushless magnet and Reluctance motor drives', Claredon press, London, 1989.
3. R.Krishnan, ' Switched Reluctance motor drives' , CRC press, 2001.
4. T.Kenjo, ' Stepping motors and their microprocessor controls', Oxford University press, New Delhi, 2000.

Modeling and Analysis of Electrical Machines

Course Code	: **17EPE124**	Credits	: 04
Contact Hours	: 4-0-0-0	CIE Marks	: 50
Total Contact Hours	: 52	SEE Marks	: 50

Course objectives

1. To study the basic concepts of modeling and reference frame theory
2. To model various DC machine under transient and steady state conditions
3. To understand the dynamic modeling of induction machines
4. To understand transformer and synchronous machine modeling.

Unit – I

Basic Concepts of Modeling: Basic two pole machine representation of commutator machines, 3-phase synchronous machine with and without damper bar and 3-phase induction machine, Kron's primitive machine-voltage, current and torque equations.

Reference Frame Theory: Real time model of a two phase induction machine, transformation to obtain constant matrices, three phase to two phase transformation, power equivalence.

11 Hours

Unit – II

DC Machine Modeling: Mathematical model of separately excited DC motor-steady state and transient state analysis, sudden application of inertia load, transfer function of separately excited DC motor, mathematical model of dc series motor, shunt motor, linearization techniques for small perturbations. **10 Hours**

Unit – III

Dynamic Modeling of Three Phase Induction Machine: Generalized model in arbitrary frame, electromagnetic torque, derivation of commonly used induction motor models-stator reference frames model, rotor reference frames model, synchronously rotating reference frames model, equations in flux linkages, per unit model,

Small Signal Equations of the Induction Machine: Derivation of small signal equations of induction machine, space phasor model, DQ flux linkages model derivation, control principle of the induction motor. **11 Hours**

Unit – IV

Transformer Modeling: Introduction, single phase transformer model, three phase transformer connections, per phase analysis, normal systems, per unit normalization, per unit three phase quantities, change of base, per unit analysis of normal system, regulating transformers for voltage and phase angle control. **10 Hours**

Unit – V

Modeling of Synchronous Machines: Introduction, voltage equations and torque equation in machine variables, stator voltage equations in arbitrary and rotor reference frame variables, Park's equations, torque equations in substitute variables, rotor angle and angle between rotors, per unit system. **10 Hours**

Reference Books

1. P.S.Bimbra, "Generalized Theory of Electrical Machines", 5thEdition, Khanna Publications, 1995.
2. R. Krishnan, "Electric Motor Drives - Modeling, Analysis & Control", PHI Learning Private Ltd, 2009.
3. P.C.Krause, Oleg Wasynczuk, Scott D.Sudhoff, "Analysis of Electrical Machinery and Drive Systems", 2ndEdition, Wiley(India),2010.
4. Arthur R Bergen and Vijay Vittal, "Power System Analysis", 2nd Edition, Pearson, 2009.
5. Chee-MunOng, "Dynamic Simulation of Electric Machinery using Matlab /Simulink",Prentice Hall, 1998.

AC And DC Drives

Course Code	: **17EPE201**	Credits	: 05
Contact Hours	: 4-0-2-0-0	CIE Marks	: 50
Total Contact Hours	: 52	SEE Marks	: 50

Course objectives

1. To introduce the fundamentals of Electric drives, their classifications, and choice.
2. To understand various aspects of DC drives and associated power electronics based controllers
3. To study concepts of AC drives and their open and closed loop control using power electronic converters
4. To understand the working principles of various special electrical drives.

Unit – I

Electric Drives: Introduction – block diagram-classification of electrical drives-choice of electrical drives- fundamental torque equation- components of load torque- steady state stability. **10 Hours**

Unit – II

DC Drives: Single Quadrant Drive: 1-Phase semi and half wave converter drives, two quadrant drive: 1-phase and 3-phase full converter drive. Two and Four quadrant drive: 1-phase and three- phase dual converter drive, different braking methods and closed loop control of DC drives. **11 Hours**

Unit – III

AC Drives: Voltage and current source inverter - inverter control-six step and PWM operation, Control of Induction motor drive -V/f and field oriented control – direct and indirect vector control **10 Hours**

Unit – IV

AC Drives: Voltage and current source inverter fed induction motor drives, stator and rotor voltage control methods, slip energy recovery drives.
Closed Loop Control of AC Drives: Stator voltage control V/f control, Slip regulation
11 Hours

Unit – V

Special Machines and Drives: Speed control of static Kramer's drive and current control.
Brushless DC motor, stepper motor and variable reluctance motor drives, Static excitation schemes of AC generator. **10 Hours**

Suggested List of Experiments:

1. Modeling and Simulation of 1, 2, and 4 quadrant single phase controlled converter connected to dc drive.
2. Modeling and Simulation of Voltage and current source inverter fed induction motor drives.
3. Modeling and Simulation of Stator voltage control and V/f control of induction motor drive.
4. Speed control of converter fed AC Drives
5. Speed control of converter fed BLDC Drives

Course Outcome:

Students completing **AC and DC Drives** course will be able to:

1. Illustrate the classifications and choice of Electric drives.
2. Control the DC drives using power electronics based controllers
3. Design power electronic converters for open loop control of AC drives
4. Demonstrate the closed loop control of AC drives using Power electronic converters.
5. Comprehend the working principles of various special electrical drives.

Reference Books

1. Bose B. K, “Modern Power Electronics & AC Drives” PHI, 2011.
2. Murphy JMD, Turnbull F.G., “Thyristor Control of AC Motors” Pergamon Press Oxford, 1998.
3. Gopal K. Dubey, Fundamentals of Electrical Drives, CRC Press, 2002
4. Mehrdad Ehsani, YiminGao, AlinEmadi, “Modern Electric, Hybrid Electric and Fuel Cell Vehicle Fundamentals, Theory and Design” SpecialIndian Edition, CRC Press 2011.
5. Haitham Abu-Rub, Jaroslaw Guzinski “High Performance Control of AC Drives “, Wiley, 2012.

Modeling and Simulation of Power Electronic Systems

Course Code	: **17EPE202**	Credits	: 05
Contact Hours	: 4-0-2-0	CIE Marks	: 50
Total Contact Hours	: 52	SEE Marks	: 50

Course objectives

1. To introduce concept of modeling of power electronics systems
2. To identify various modeling techniques used for switched mode power supply and Electrical Motors
3. Illustrate traditional and modern design techniques for power electronics systems
4. Introduce the discrete computational essentials useful in modeling power electronic systems.

Unit – I

Computer Simulation of Power Electronic Converters and Systems:
Types of analysis, circuit-oriented simulators, equation solvers, comparison of circuit oriented simulators and equation solvers.
Modeling of Systems: Input-Output relations, differential equations and linearization, state space representation, transfer function representation, modeling of an armature controlled DC Motor, poles and zeros **11 Hours**

Unit – II

SMPS Modeling: Circuit averaging method of modeling approach for switched power electronic circuits, State Space Averaged model for an ideal Buck Converter, ideal Boost Converter, ideal Buck Boost Converter and an ideal Cuk Converter.
Space vector modeling: representation of space vectors in orthogonal co-ordinates, space vector transformations **11 Hours**

Unit – III

Modeling of induction motor, state space representation of the d-q model of the induction motor,
Traditional Design techniques to power converters: Bode diagram method, PID controller design, Root locus method. **10 Hours**

Unit – IV

Modern Design Technique: State space method, Full state feedback, Regulator design by pole placement, estimator design, tracker, controller design controlling voltage, controlling current. **10 Hours**

Unit – V

Review of Control of DC Motor, BLDC Motor: Introduction, control of BLDC.
Closed loop Control of Induction Motor:
Synchronous Machine: Dynamic performance of a synchronous machine using 'D-Q-0 model,
PMSM: Introduction, Type (SPMSM, IPMSM), **10 Hours**

Suggested Lab Experiments:

1. Model an ideal buck converter using transfer function and state space methods. Simulation of the same buck converter using MATLAB and Compare the results obtained in above methods.
2. Using single input single output design tool in MATLAB Verify the separately excited dc motor model for its stability using Bode plot. Design a controller for the dc motor model. Verify the stability of the system using Bode plot.
3. Using single input single output design tool in MATLAB, verify the separately excited dc motor model for its stability using root locus. Design a controller for the dc motor model. Verify the stability of the system using root locus.

Course Outcome:

Students completing **Modeling and Simulation of Power Electronic Systems** course will be able to:

1. Identify equation solvers and circuit oriented simulation software and Model a system using various methods.
2. Model power electronics systems using circuit averaging technique and induction motor using state space modeling.
3. Model the Induction motor and Illustrate various Controller design techniques using Bode, PID controller, Root locus methods.
4. Illustrate controller design using state space technique, regulator, tracker, estimator design.
5. Model various electrical machines and their associated control techniques.

Reference Books

1. L. Umanand, "Power Electronics Essentials and Applications", 1st Edition, John Wiley & Sons, 2009.
2. M B Patil, V Ramanarayan, VTR, “Simulation of Power Electronic Circuits”, Narosa Publishing House.
3. Christophe P Basso: Switched mode power supplies: Spice Simulation and Practical Designs, BPB Publications, New Delhi, 2014
4. Ned Mohan, Tore M. Undeland, William P. Robbins, “Power Electronics Converters, Applications, and Design”, 3rd Edition, John Wiley & Sons, 2009.
5. Robert W. Erickson, Dragan Maksimovic, “Fundamentals of Power Electronics”, Springer; 2nd ed. 2001.

Application of Power Electronics to HVDC and FACTS

Course Code	: **17EPE203**	Credits	: 05
Contact Hours	: 4-0-2-0	CIE Marks	: 50
Total Contact Hours	: 52	SEE Marks	: 50

Course objectives

1. To know the various aspects of High Voltage DC converters
2. To study control schemes of HVDC converters and the requirements of smoothing reactor.
3. To introduce FACTS controllers and its associated power electronics concepts.
4. To study various FACTS devices and their control

Unit – I

DC Power Transmission Technology: Introduction, comparison with AC transmission, application of DC transmission

HVDC Converters: Introduction to Line commutated converter, choice of converter configuration for any pulse number, analysis of 6 pulse Graetz bridge converter without overlap, effect of source inductance. Analysis of converter in two and three, and three and four valve conduction modes, twelve pulse converter. Capacitor Commutated converter. **10 Hours**

Unit – II

Control of Converters and HVDC link: DC link control principles, converter control characteristics, firing angle control, current and extinction angle control, Starting and stopping of DC link, Power control, Frequency control, Reactive power control, Tap changer control, Emergency control and Telecommunication requirements..

Smoothing Reactor and DC line: Smoothing reactors and its design, Detection and protection of faults in dc line, DC breaker.

Multi Terminal DC Systems: Introduction, applications, types.

Voltage Source Converter: Introduction, Two and Three level voltage source converters, Pulse Width Modulation, Control of voltage source converter based HVDC**.** **12 Hours**

Unit – III

FACTS: Basics of power transmission networks - control of power flow in AC - transmission line, Transmission, interconnection, power flow and dynamic stability consideration of a transmission interconnection, relative importance of controllable parameters. Classification of flexible AC transmission system controllers, Benefits of FACTS Controller – application of FACTS controllers in distribution systems.

Shunt and Series Compensation: Objectives of Shunt Compensation, Midpoint voltage regulation for line segmentation, End of line voltage support to prevent voltage instability, Objectives of series Compensation, Improvement of Transient stability, Power oscillation damping**.** **10 Hours**

Unit – IV

Variable Impedance FACTS controllers:

Static Var compensator: Methods of controllable Var generation**,** Analysis of SVC – Power angle curve with SVC, Configuration of SVC- FC-TCR, TSC-TCR, SVC Controller – Block diagram of SVC Voltage Controller, Susceptence Regulator, modeling of SVC – applications of SVC.

Thyristor and GTO Controlled Series Capacitor: Introduction - basic concepts of controlled series compensation -operation of TCSC - analysis of TCSC- control of TCSC - GTO thyristor controlled series capacitor (GCSC) - mitigation of sub synchronous resonance with TCSC and GCSC - applications of TCSC. **10 Hours**

Unit – V

VSC Based FACTS Controllers:

Static Synchronous Compensator (STATCOM): Introduction - principle of operation of STATCOM - a simplified analysis of a three phase six pulse STATCOM - analysis of a six pulse VSC using switching functions - multi-pulse converters. Control of type 2 converters - control of type I Converters - multilevel voltage source converters - applications of STATCOM.

SSSC : SSSC-operation of SSSC , control of power flow – Description, modeling of SSSC, control of SSSC using Type-2 and Type-1 VSC,

Introduction to Unified Power Flow Controller (UPFC) and Interline Power Flow Controller (IPFC) – Basic operating principles. **10 Hours**

Suggested Lab Experiments:

Note: Suggested to use MATLAB / SIMULINK Software for the simulation of experiments listed below.

1. Modeling of 6 pulse Graetz bridge HVDC Terminal
2. Modeling of 6 pulse and 12 pulse VSC using 2-level and 3-level
3. Modeling of TCR, SVC, TCSC
4. 3 phase to d-q transformation and simulation of d-q based model of STATCOM
5. Simulation of d-q based model of SSSC

Reference Books

1. K. R. Padiyar, "HVDC Power Transmission Systems", New Age International, 2012.
2. E.W.Kimbark "Direct Current Transmission", Vol.1, Wiley Inter-Science, London, 2006.
3. Arrilaga, "High Voltage Direct Current Transmission", The Institute of Engineering and Technology, 2ndEdition, 2007.
4. S Kamakshaiah and V Kamaraju, "HVDC Transmission", TMH, 2011.
5. K.R Padiyar, "FACTS Controllers in Power Transmission and Distribution", New Age International, 2007.
6. Narain G Hingorani and L. Gyugyi, "Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems", Wiley India, 2011.
7. Mohan Mathur, R., Rajiv. K. Varma, "Thyristor – Based Facts Controllers for Electrical Transmission Systems", IEEE press and John Wiley & Sons, Inc. 2002

Research Experience through Practice-II

Course Code	: **17EPE204**	Credits	: 02
Contact Hours	: 0-0-4-0	CIE Marks	: 100
Total Contact Hours	: 52	SEE Marks	: -

Research Experience through Practice-II

- The students are expected to carry out Mathematical modeling/Design calculations/computer simulations/Preliminary experimentation/testing of the research problems identified during **Research Experience through Practice-I** carried out in the first semester.
- At the end of the second semester, students are expected to submit a full research paper based on the Mathematical modelling/ Design calculations/computer simulations/Preliminary experimentation/testing carried out during second semester.

Power Quality Enhancement and Custom Power Devices

Course Code	: **17EPE211**	Credits	: 04
Contact Hours	: 4-0-0-0	CIE Marks	: 50
Total Contact Hours	: 52	SEE Marks	: 50

Course objectives

1. To study the characterization of electric power quality, their analysis and conventional mitigation techniques
2. To introduce the custom power devices, their characteristics and related issues
3. To understand the working of various custom devices like DSTATCOM, DVR, UPQC.

Unit – I

Introduction and Characterization of Electric Power Quality: Electric Power Quality, Power Electronic applications in Power Distribution Systems. Power Quality terms and Definitions, Power Quality Problems.

Analysis and Conventional Mitigation Methods: Analysis of Power Outages, Analysis of Unbalance, Analysis of Distortion, Analysis of Voltage Sag, Analysis of Voltage Flicker, Harmonic Reduction, Voltage Sag or Dip Reduction. **11 Hours**

Unit – II

Custom Power Devices: Introduction, Utility-Customer Interface, Custom Power Devices, Custom Power Park, Status of Application of CP Devices.

Solid State Limiting, Breaking and Transferring Devices: Solid State Current Limiter, Solid State Breaker, Issues in Limiting and Switching operations, Solid State Transfer Switch, Sag/Swell Detection Algorithms. **11 Hours**

Unit – III

Load Compensation using DSTATCOM: Compensating Single-Phase Loads, Ideal Three-Phase Shunt Compensator Structure, Generating Reference Currents Using Instantaneous PQ Theory, Generating reference currents using instantaneous Symmetrical Components. **10 Hours**

Unit – IV

Realization and Control of DSTATCOM: DSTATCOM Structure, Control of DSTATCOM Connected to a Stiff Source, DSTATCOM Connected to weak Supply Point, DSTATCOM Current Control through Phasors, DSTATCOM in Voltage Control Mode. **10 Hours**

Unit – V

Series Compensation of Power Distribution System: Rectifier Supported DVR, DC Capacitor Supported DVR, DVR Structure, Voltage Restoration, Series Active Filter.

Unified Power Quality Conditioner: UPQC Configurations, Types of UPQC, Right-Shunt UPQC Characteristics, Left-Shunt UPQC Characteristics **10 Hours**

Reference Books

1. Arindam Ghosh et.al, Power Quality Enhancement Using Custom Power Devices, Kluwer Academic Publishers,2002.
2. Power Quality Problems and Mitigation Techniques, Bhim Singh, Ambrish Chandra, Kamal Al-Haddad, Wiley 2015
3. Math H J Bollen, “Understanding Power Quality Problems; Voltage Sags and Interruptions”, Wiley India, 2011.
4. Roger C Dugan, et.al, “Electrical Power Systems Quality”, 3rd Edition, TMH, 2012.
5. G T Heydt, “Electric Power Quality”, Stars in Circle Publications, 1991.
6. Ewald F Fuchs, et.el, “Power Quality in Power System and Electrical Machines”, Academic Press, Elsevier, 2009.
7. B. Shankaran “Power Quality”, CRC Press, 2013

Multi-Terminal DC Grids

Course Code	: **17EPE212**	Credits	: 04
Contact Hours	: 4-0-0-0	CIE Marks	: 50
Total Contact Hours	: 52	SEE Marks	: 50

Course objectives:

- To provide the fundamentals of MTDC grids, their network architectures, components and control modes and basics of voltage sourced converters.
- To explain modeling, simulation and analysis of AC- MTDC grids
- To explain the concept of power sharing in MTDC grid, load flow solution and post contingency operation
- To explain protection issues of MTDC grids, including the DC circuit breakers and fault blocking VSC systems and protection strategies.

Unit-I

Fundamentals: Introduction, Rationale behind MTDC Grids, Network Architectures of MTDC Grids, Enabling Technologies and Components of MTDC Grids, Control Modes in MTDC Grid, Challenges for MTDC Grids, Configurations of MTDC Converter Stations, Research Initiatives on MTDC Grids.

Voltage-Sourced Converter (VSC): Introduction, Ideal Voltage-Sourced Converter, Practical Voltage-Sourced Converter. **11 Hours**

Unit-II

Voltage-Sourced Converter (continued): Control, Simulation.

Modelling, Analysis, and Simulation of AC–MTDC Grids: Introduction, MTDC Grid Model.

09 Hours

Unit-III

Modelling, Analysis, and Simulation of AC–MTDC Grids (continued): AC Grid Model, AC–MTDC Load flow Analysis, AC–MTDC Grid Model for Nonlinear Dynamic Simulation, Small-signal Stability Analysis of AC–MTDC Grid, and Transient Stability Analysis of AC–MTDC Grid.

10 Hours

Unit-IV

Modelling, Analysis, and Simulation of AC–MTDC Grids (continued): Case Study 1: The North Sea Benchmark System, Case Study 2: MTDC Grid Connected to Equivalent AC Systems, Case Study 3: MTDC Grid Connected to Multi-machine AC System.

Autonomous Power Sharing: Introduction, Steady-state Operating Characteristics, Concept of Power Sharing, Power Sharing in MTDC Grid, AC–MTDC Grid Load flow Solution, Post-contingency Operation, Linear Model, Case Study. **12 Hours**

Unit-V

Frequency Support: Introduction, Fundamentals of Frequency Control, Inertial and Primary Frequency Support from Wind Farms, Wind Farms in Secondary Frequency Control (AGC), Modified Droop Control for Frequency Support, AC–MTDC Load Flow Solution, Post-Contingency Operation, Case Study.

Protection of MTDC Grids: Introduction, Converter Station Protection, DC Cable Fault Response, Fault-blocking Converters, DC Circuit Breakers, Protection Strategies. **10 Hours**

Course outcomes:

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

1. Explain the fundamentals of MTDC grids, their network architectures, components and control modes
2. Differentiate ideal and practical voltage sourced converters.
3. Simulate AC- MTDC grids for the analysis.
4. Explain the concept of power sharing in MTDC grid, load flow solution and post contingency operation.
5. Explain frequency support from wind farms.
6. Explain protection issues of MTDC grids, including the DC circuit breakers and fault blocking VSC systems and protection strategies.

Text Book:

1. Multi-Terminal Direct-Current Grids Modelling, Analysis, and Control, Nilanjan Ray Chaudhuri et al, Wiley, 2014

Smart Grid

Course Code	: **17EPE213**	Credits	: 04
Contact Hours	: 4-0-0-0	CIE Marks	: 50
Total Contact Hours	: 52	SEE Marks	: 50

Course objectives

1. To study the Information and Communication Technologies related to smart grid.
2. To understand the Information security and different sensing and automation techniques.
3. To know the principles of Distribution management systems and transmission system operation for smart equipment's.
4. To study the power quality issues and their management in smart grid
5. To know the importance of micro grids and distributed energy resources.

Unit – I

The Smart Grid: Introduction, Information And Communication Technologies: Data communication, Switching techniques, Communication channels, Layered architecture and protocols

Communication technologies for the Smart Grid - Communication technologies, Standards for information exchange **11 Hours**

Unit – II

Information security for the Smart Grid – Introduction, Encryption and decryption, Authentication, Digital signatures, Cyber security standards

Sensing, Measurement, Control And Automation Technologies: Smart metering - An overview of the hardware used, Communications infrastructure and protocols for smart metering**,** Demand-side integration **11 Hours**

Unit – III

Distribution automation equipment – Introduction,

Distribution management systems – Introduction, Data sources and associated external systems, Modelling and analysis tools,

Transmission system operation – Phasor measurement units, Wide area applications

10 Hours

Unit – IV

Power Quality Management in Smart Grid: Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit. Fault current limiting.

10 Hours

Unit – V

Micro grids and Distributed Energy Resources - Concept of micro grid, Microgrid and Smart Grid Comparison.need & applications of micro grid, formation of micro grid, protection & control of micro grid. Integration of renewable energy sources with microgrid.

Role of Energy storage smart grid – Introduction, Energy storage technologies, flow batteries, fuel cells. **10 Hours**

Course Outcome:

Students completing **Smart Grid** course will be able to:

1. Introduce the Information and Communication Technologies related to smart grid
2. Illustrate the Information security and different sensing and automation techniques
3. Explain the principles of Distribution management systems and transmission system operation for smart equipment's.
4. Illustrate the interfacing of power electronics devices to integrate the renewable energy sources into smart grid.
5. Comprehend the importance of shunt compensation with energy storage

Reference Books

1. "Smart Grid - Technology And Applications", Janaka Ekanayake, Kithsiri Liyanage, John Wiley & Sons, Ltd., Publication, 2012
2. "Power Electronics in Smart Electrical Energy Networks", Ryszard Strzelecki, Grzegorz Benysek, Springer Publication, ISBN-13: 9781848003170, 2008
3. "The Smart Grid: Enabling Energy Efficiency and Demand Response" Clark W. Gellings, P.E, The Fairmont Press, Inc.2009
4. "SMART GRID - Fundamentals of Design and Analysis" James Momoh, IEEE Press, A JOHN WILEY & SONS, INC., PUBLICATION - 2012
5. Peter S. Fox-Penner, "Smart Power: Climate Change, the Smart Grid, and the Future of Electric Utilities".1st Edition, 2010.
6. Ali Keyhani, Mohammad N. Marwali, Min Dai "Integration of Green and Renewable Energy in Electric Power Systems", Wiley.2010.

Hybrid Electric Vehicles

Course Code	: **17EPE214**	Credits	: 04
Contact Hours	: 4-0-0-0	CIE Marks	: 50
Total Contact Hours	: 52	SEE Marks	: 50

Course objectives:

- To explain the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals.
- To explain plug – in hybrid electric vehicle architecture, design and component sizing and the power electronics devices used in hybrid electric vehicles.
- To discuss various electric drives suitable for hybrid electric vehicles
- To discuss different energy storage technologies used for hybrid electric vehicles and their control.
- To explain modeling and simulation of electric hybrid vehicles by different techniques, sizing of components and design optimization and energy management.

Unit-I

Introduction: Sustainable Transportation, A Brief History of HEVs, Why EVs Emerged and Failed, Architectures of HEVs, Interdisciplinary Nature of HEVs, State of the Art of HEVs, Challenges and Key Technology of HEVs.

Hybridization of the Automobile: Vehicle Basics, Basics of the EV, Basics of the HEV, Basics of Plug-In Hybrid Electric Vehicle (PHEV), Basics of Fuel Cell Vehicles (FCVs).

HEV Fundamentals: Introduction, Vehicle Model, Vehicle Performance, EV Powertrain Component Sizing, Series Hybrid Vehicle, Parallel Hybrid Vehicle, Wheel Slip Dynamics.

12 Hours

Unit-II

Plug-in Hybrid Electric Vehicles: Introduction to PHEVs, PHEV Architectures, Equivalent Electric Range of Blended PHEVs, Fuel Economy of PHEVs, Power Management of PHEVs, PHEV Design and Component Sizing, Component Sizing of EREVs, Component Sizing of Blended PHEVs, HEV to PHEV Conversions, Other Topics on PHEVs, Vehicle-to-Grid Technology.

Power Electronics in HEVs: Introduction, Principle of Power Electronics, Rectifiers Used in HEVs, Buck Converter Used in HEVs, Non-isolated Bidirectional DC–DC Converter, Voltage Source Inverter, Current Source Inverter, Isolated Bidirectional DC–DC Converter, PWM Rectifier in HEVs, EV and PHEV Battery Chargers, Modelling and Simulation of HEV Power Electronics, Emerging Power Electronics Devices, Circuit Packaging, Thermal Management of HEV Power Electronics. **12 Hours**

Unit-III

Electric Machines and Drives in HEVs: Introduction, Induction Motor Drives, Permanent Magnet Motor Drives, Switched Reluctance Motors, Doubly Salient Permanent Magnet Machines, Design and Sizing of Traction Motors. **09 Hours**

Unit-IV

Energy Storage Devices: Introduction, Battery Characterization, Comparison of Different Energy Storage Technologies for HEVs, Modelling Based on Equivalent Electric Circuits, Battery Charging Control, Charge Management of Storage Devices, Flywheel Energy Storage System, Hydraulic Energy Storage System, Fuel Cells and Hybrid Fuel Cell Energy Storage System.

09 Hours

Unit-V

Modelling of Electric and Hybrid Vehicles: Introduction, Fundamentals of Vehicle System Modelling, HEV Modelling Physics-Based Modelling, Bond Graph and Other Modelling Techniques, Consideration of Numerical Integration Methods.

Vehicular Power Control Strategy and Energy Management: A Generic Framework, Definition, and Needs, Methodology to Implement, Benefits of Energy Management. **10 Hours**

Course outcomes:

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

1. Explain the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals.
2. Explain plug – in hybrid electric vehicle architecture, design and component sizing.
3. Explain the use of different power electronics devices in hybrid electric vehicles.
4. Suggest a suitable electric drive for a specific type of hybrid electric vehicle.
5. Explain the use of different energy storage devices used for hybrid electric vehicles, their technologies and control.
6. Simulate electric hybrid vehicles by different techniques for the performance analysis.

Took Book

1. Hybrid Electric Vehicles principles and Applications with Practical Perspectives, Chris Mi,M. Abul Masrur,David Wenzhong Gao, Wiley, 2011.

PWM controlled Power Electronic Converters

Course Code	: **17EPE221**	Credits	: 04
Contact Hours	: 4-0-0-0	CIE Marks	: 50
Total Contact Hours	: 52	SEE Marks	: 50

Course objectives

1. To introduce the concept of PWM and their application to power electronics control
2. To study various PWM Techniques and their modeling.
3. To know the various switching and conduction losses associated with power devices
4. To study the concept of converters with compensation.

Unit – I

PWM DC/DC Converters: Analysis of Galvanically Isolated Forward Converter, Boost Converter, Push – Pull (Symmetric) Converters - Analysis of Idealized Circuit in Continuous Mode, Output Characteristics, Selection of Components, DC Pre-magnetization of the Core, Half-Bridge Converter, Bridge Converter, Hamilton Circuit, Ćuk Converters - Elimination of the Current Ripple, Ćuk Converters with Galvanic Isolation. **10 Hours**

Unit – II

Control Modules: Basic Principles and Characteristics of PWM Control Modules - Circuit Analysis, Simple PWM, Voltage-Controlled PWM, Current-Controlled PWM- Compensated PWM.
DC/AC Converters – Inverters: Single-Phase Voltage Inverters - Pulse-Controlled Output Voltage, Pulse-Width Modulated Inverters - Unipolar PWM, Three-Phase Inverters-Over modulation (ma > 1), Asynchronous PWM, Space Vector Modulation - Space Vector Modulation: Basic Principles, Application of Space Vector Modulation Technique, Direct and Inverse Sequencing, Real Drive Influence. **12 Hours**

Unit – III

AC/DC Converters – Rectifiers: Rectifiers with Circuit for Power Factor Correction, Active Rectifier - Active Rectifier with Hysteresis Current Controller, PWM Rectifiers - Advanced Control Techniques of PWM Rectifiers , PWM Rectifier with Current Output, PWM Rectifiers in Active Filters, Some Topologies of PWM Rectifiers, Applications of PWM Rectifiers.
10 Hours

Unit – IV

Resonant Converters: Resonant Circuits - Resonant Converters of Class D, Series Resonant Converters, Parallel Resonant Converters, Series – Parallel Resonant Converter, Series Resonant Converters Based on GTO Thyristors, Class E Resonant Converters, DC/DC Converters Based on Resonant Switches - ZCS Quasi-resonant Converters, ZVS Quasi-resonant Converters, Multiresonant Converters, ZVS Resonant DC/AC Converters, Soft Switching PWM DC/DC Converters **10 Hours**

Unit – V

AC/AC Converters: Single-Phase AC/AC Voltage Converters - Time Proportional Control, Three-Phase Converters, Frequency Converters, Direct Frequency Converters, Introduction to AC/AC Matrix Converters - Basic Characteristics, Bidirectional Switches, Realization of Input Filter, Current Commutation, Protection of Matrix Converter, Application of Matrix Converter.
Introduction to Multilevel Converters: Basic Characteristics -Multilevel DC/DC Converters, Time Interval: $nT < t < nT + DT$, $n = 0, 1, 2$,Time Interval: $nT + DT < t < (n + 1)T$, Multilevel Inverters - Cascaded H-Bridge Inverters, Diode-Clamped Multilevel Inverters, Flying Capacitor Multilevel Inverter. **10 Hours**

Course outcomes:

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

1. Use the knowledge of PWM techniques in controlling different power electronic converters.
2. Apply the knowledge of power electronics in design and analysis of DC –DC PWM converters.

3. Design and analyze DC –AC and AC – DC converters and control their operation using PWM techniques.
4. Design and analyze different resonant converters and their control circuits.
5. Analyze AC – AC converters and multilevel converters.

Reference Books

1. Branko L. Dokić Branko Blanu, "Power Electronics Converters and Regulators", Springer (International Publishing, Switzerland) 3rd Edition, 2015
2. Mohan, Undeland and Robbins, "Power Electronics: Converter, Applications and Design", Wiley India, 2011.
3. D. Grahame Holmes and Thomas A. Lipo "Pulse Width Modulation For Power Converters Principles and Practice" IEEE Press 2003
4. V. T. Ranganathan, Course Notes on Electric Drives, Indian Institute of Science, Bangalore 2004
5. Erickson RW, "Fundamentals of Power Electronics", Chapman Hall, 1997.
6. Joseph Vithyathil, "Power Electronics- Principles and Applications", TMH, 2011.
7. Application notes and datasheets from Power Semiconductor Switch manufacturers like Infineon, MuRata
8. Relevant technical papers published.

Converters for Solar and Wind Power Systems

Course Code	: **17EPE222**	Credits	: 04
Contact Hours	: 4-0-0-0	CIE Marks	: 50
Total Contact Hours	: 52	SEE Marks	: 50

Course objectives

1. To introduce various RES which could be converted to electricity
2. To illustrate possible RE conversion systems like WECS, photovoltaic and its associated technologies
3. To introduce energy storage technologies and its importance.
4. To explain possible hybrid energy systems and some case studies.

Unit – I

Introduction: The Grid tie Converter –Grid Integration of WT and PV Systems. International Regulations.

Photovoltaic Inverter Structures: Introduction, Inverter Structures Derived from H-Bridge Topology, Inverter Structures Derived from NPC Topology, Typical PV Inverter Structures, Three-Phase PV Inverters, Control Structures.

Grid Requirements for PV: Introduction, Response to Abnormal Grid Conditions, Power Quality, Anti-islanding Requirements **11 Hours**

Unit – II

Grid Synchronization of Single-Phase Power Converters: Introduction, Grid Synchronization Techniques for Single-Phase Systems, Phase Detection Based on In-Quadrature Signals, PLLs Based on In-Quadrature Signal Generation, PLLs Based on Adaptive Filtering, The SOGI Frequency-Locked Loop.

Islanding Detection: Introduction, Non-detection Zone, Overview of Islanding Detection Methods, Passive Islanding Detection Methods, Active Islanding Detection Methods

11 Hours

Unit – III

Grid Converter Structures for Wind Turbine Systems: Introduction, Configurations, Grid Power Converter Topologies and Control.

Grid Requirements for WT Systems: Introduction, Grid Code Evolution, Frequency and Voltage Deviation under Normal Operation, Active Power Control in Normal Operation, Reactive Power Control in Normal Operation Behavior under Grid Disturbances.

Grid Converter Control for WTS: Introduction, Model of the Converter, AC Voltage and DC Voltage Control, Voltage Oriented Control and Direct Power Control, Stand-alone, Micro-grid, Droop Control and Grid Supporting. **10 Hours**

Unit – IV

Grid Synchronization in Three-Phase Power Converters: Introduction, The Three-Phase Voltage Vector under Grid Faults, The Synchronous Reference Frame PLL under Unbalanced and Distorted Grid Conditions, The Decoupled Double Synchronous Reference Frame PLL (DDSRF-PLL), The Double Second-Order Generalized Integrator FLL (DSOGI-FLL).

09 Hours

Unit – V

Control of Grid Converters under Grid Faults: Introduction, Overview of Control Techniques for Grid-Connected Converters under Unbalanced Grid Voltage Conditions, Control Structures for Unbalanced Current Injection, Power Control under Unbalanced Grid Conditions, Flexible Power Control with Current Limitation.

Grid Filter Design: Introduction, Filter Topologies, Design Considerations, Practical Examples of LCL Filters and Grid Interactions, Resonance Problem and Damping Solutions, Nonlinear Behaviour of the Filter. **11 Hours**

Course outcomes:

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

1. Explain developments in the PV and WT penetrations in the worldwide power systems.

2. Discuss the various high-efficiency topologies for PV inverters and generic control structures.
3. Describe the grid requirements for PV installations, and different quadrature signal generator methods,
4. Explain grid synchronization techniques for single phase power converters.
5. Explain islanding detection methods and typical WT grid converter topologies, control structures, the grid requirements for WT grid connection and the grid codes.
6. Explain grid synchronization of three phase power converters and new robust synchronization structures to cope with the unbalance and distorted grid conditions.
7. Explain the grid converter control structures for WT and the control issue for the case of grid faults.
8. Design grid interface filters used to damp the resonance for LCL filters and methods for controlling the grid current.

Text Book

1. Grid Converters for Photovoltaic and Wind Power Systems, Remus Teodorescu at al, Wiley, 2011

Reference Books

1. S. N. Bhadra, D. Kastha, & S. Banerjee "Wind Electrical Systems", Oxford University Press, 2009
2. Rashid .M. H "Power Electronics Hand Book", Academic press, 2001.

DSP Applications to Drives

Course Code	: **17EPE223**	Credits	: 04
Contact Hours	: 4-0-0-0	CIE Marks	: 50
Total Contact Hours	: 52	SEE Marks	: 50

Course objectives

1. To introduce the DSP Controller TMS320LF2407 its architecture, characteristics and various features.
2. To explore the application of DSP controllers in controlling SMPS
3. To explore the application of DSP controllers in controlling various drives like stepper motor, PMDC, BLDC, PMSM and Induction motors using space vector and PWM techniques.

Unit – I

Introduction to the TMS320LF2407 DSP controller, peripherals, C2xx DSP CPU architecture and instruction set (brief), addressing modes, overview of system configuration registers.

10 Hours

Unit – II

General Purpose Input/output (GPIO) functionality: Pin multiplexing and general purpose I/O overview, using general purpose I/O ports. Interrupts: Introduction, hierarchy, interrupt control registers (ICRs), initializing and servicing interrupts. Analog-to-Digital Converter (ADC): Overview, operation, sequencer configuration of ADCs, sequencer operating modes - start/stop sequencer mode and continuous auto-sequencer mode, triggering sources for ADCs, ADC control registers. **10 Hours**

Unit – III

Event Managers: Overview, event manager interrupts, general purpose timers, compare units, capture units and Quadrature Encoded Pulse(QEP) circuitry, general event manager information. **08 Hours**

Unit – IV

DSP Based Applications

DSP based vector control of induction motors: Overview of three phase induction motor operation, overview of induction motor speed control, overview of speed control system components, Implementation of field oriented control of induction motor – software organization, base value and per-unit model, numerical considerations, numerical format determination, current measurement, speed measurement, speed estimation during high speed region and low speed region, current model, PI regulator, calculation of sine and cosine functions. **12 Hours**

Unit – V

Overview of Park's and Clarke's transformations, implementing Park's and Clarke's transformations on the LF240X.

DSP based control of stepper motors: Overview of the principles and operation of hybrid stepper motors, overview of a stepper motor drive system, implementation of a stepper motor control system using LF2407 DSP. 23 DSP based control of permanent magnet brushless motors : Overview of principles of BLDC machines and torque generation, overview of a BLDC control system, implementation of a BLDC control system using LF2407 DSP. **12 Hours**

Reference Books

1. Hamid Toliyat and Steven Campbell, "DSP-Based Electromechanical Motion Control", CRC Press, 2011.
2. P.C.Krause, Oleg Wasynczuk, Scott D.Sudhoff, "Analysis of Electrical Machinery and Drive Systems", 2nd Edition, Wiley India,2010
3. Chee-Mun Ong, "Dynamic Simulation of Electric Machinery using Matlab / Simulink", Prentice Hall,1998.
4. L.Umanand, "Power Electronics : Essentials and Applications", Wiley, 2013.

Multilevel Converters for Industrial Applications

Course Code	: **17EPE224**	Credits	: 04
Contact Hours	: 4-0-0-0	CIE Marks	: 50
Total Contact Hours	: 52	SEE Marks	: 50

Course objectives:

- To provide an overview of medium-voltage power converters and their applications.
- To describe the generalized multilevel converter topology and to derive the classic converters with a common DC bus and to analyze the common characteristics of the symmetric topologies.
- Explain the analysis of the operation of the diode-clamped multilevel converter, and a multilevel space vector modulation and to characterize the balancing boundary of the passive front-end converter
- To describe the operation and analysis of the flying capacitor multilevel converter.
- To explain asymmetric topology with hybrid modulation and a common DC source called a cascade asymmetric multilevel converter (CAMC) with five voltage levels and its advantages.
- To analyse the behaviour of the CAMC as a distribution static compensator (DSTATCOM) and shunt active power filter in improving the power quality in medium-voltage distribution systems as custom power devices.
- To analyse the behaviour of the diode-clamped topology configured as a back-to-back converter for several working conditions.

Unit-I

Converters: Introduction, Medium-Voltage Power Converters, Multilevel Converters, Applications.

Multilevel Topologies: Introduction, Generalized Topology with a Common DC Bus, Converters Derived from the Generalized Topology, Symmetric Topologies without a Common DC Link, Summary of Symmetric Topologies, Asymmetric Topologies. **10 Hours**

Unit-II

Diode-Clamped Multilevel Converter: Introduction, Converter Structure and Functional Description, Modulation of Multilevel Converters, Voltage Balance Control, Effectiveness Boundary of Voltage Balancing in DCMC Converters, Performance Results. **10 Hours**

Unit-III

Flying Capacitor Multilevel Converter: Introduction, Flying Capacitor Topology, Modulation Scheme for the FCMC, Dynamic Voltage Balance of the FCMC.

Cascade Asymmetric Multilevel Converter (CAMC): Introduction, General Characteristics of the CAMC, CAMC Three-Phase Inverter, Comparison of the Five-Level Topologies. **12 Hours**

Unit-IV

Case Study 1: DSTATCOM Built with a Cascade Asymmetric Multilevel Converter: Introduction, Compensation Principles, CAMC Model, Reactive Power and Harmonics Compensation. **10 Hours**

Unit-V

Case Study 2: Medium-Voltage Motor Drive Built with DCMC: Introduction, Back-to-Back DCMC Converter, Unified Predictive Controller of the Back-to-Back DCMC in an IM Drive Application, Performance Evaluation. **10 Hours**

Course outcomes:

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

1. Explain the working of medium-voltage power converters and their applications.
2. Explain multilevel, symmetric and asymmetric topologies.
3. Explain the structure and operation of the diode-clamped multilevel converter, and a multilevel space vector modulation.
4. Characterize the balancing boundary of the passive front-end converter.
5. Describe the operation and analysis of the flying capacitor multilevel converter.
6. Discuss the characteristics topologies of the Cascade Asymmetric Multilevel Controller.

7. Explain the working of a distribution static compensator (DSTATCOM) built with CAMC for reactive power and harmonic compensation.
8. Evaluate the performance of back-to-back converter in an induction motor drive for several working conditions.

Text Book

1. Multilevel Converters for Industrial Applications, Sergio Alberto González, Santiago Andrés Verne, María Inés Valla, CRC Press, 2014

M. TECH. POWER ELECTRONICS
(AUTONOMOUS SCHEME)
III SEMESTER

Revised at the BOS meeting on **20th May 2017**

Sl.	Code	Subject	Practical/Field Work/Assignment	CIE	SEE	Credits
1.	17EPE301	Industrial Training/ Mini-Project	Full time 8 weeks	50 (report) 50(presentation)	-	8
2.	17EPE302	Seminar on Special Topics	----	100	-	2
3.	17EPE303	Project Part -I	Full time 10 weeks	100 (Report) 100(Presentation)	-	10
		Total		400	-	20

Note:

1. 17EPE301: Industrial Internship / Mini Project – To be evaluated after 8 weeks from the date of commencement of 3rd semester. Evaluation – 50 (Report) + 50 (Presentation)
2. 17EPE303: Project Part -I - The students give a minimum of two seminars on the progress of the project. The Department Committee (with guide as one of the member) accesses the progress of the work and the final assessment of Report and presentation will be done at the end of 3rd semester for 100 Marks each respectively.

17EPE302	Special Topic Seminar		
Credits	2	CIE	100+ --
Total No. of seminar Hours / week	2	Total Marks	100

The aim of the seminar is to inculcate self-learning, face audience, enhance communication skill, involve in group discussion and present his ideas.
Each student, under the guidance of a Faculty, is required to

i) Choose a topic of his/her interest relevant to the Course of Specialization
ii) Carryout literature survey, organize the subject topics in a systematic order
iii) Prepare the report with own sentences
iv) Type the matter to acquaint with the use of Micro-soft equation and drawing tools or any such facilities
v) Present the seminar topic at least for 20 minutes orally and/or through power point slides
vi) Answer the queries and involve in debate/discussion lasting for about 10 minutes
vii) Submit two copies of the typed report with a list of references

The participants shall take part in discussion to foster friendly and stimulating environment in which the students are motivated to reach high standards and become self-confident.
The internal assessment marks shall be awarded by a committee consisting of at least two staff members based on the relevance of the topic, presentation skill, participation in the question and answer session and quality of report.

M. TECH. POWER ELECTRONICS
(AUTONOMOUS SCHEME)
IV Semester

Sl.	**Code**	**Subject**	Practical/Field Work	Duration of Exam in Hours	CIE	SEE	**Credits**
1.	17EPE401	Project Part-II	Full Time 20 Weeks	-	200 [PPE*-I – 100 PPE-II – 100]	200	30
		Total		-	400		30
GRAND TOTAL From 1st to 4th semester: 100 credits (2000 marks)							

* PPE – Project Progress Evaluation

1. 17EPE401: Project –Part II - CIE will consist of two Project Progress Evaluation by the Department Committee for100 marks each. The project report will be evaluated by the Guide and the external examiner. Viva-Voce will be conducted by a committee consisting of the following:
   (a) Chairman, BOE (PG)
   (b) Project Guide
   (c) External Examiner