Dr. Ambedkar Institute of Technology

Department of Electrical and Electronics Engineering

The NAAC documents enclosed are verified and approved.

Jayaramu G 5/11/22

HOD

Dept. of EEE

HOD
Department of Electrical and Electronics Engg.
Dr. Ambedkar Institute of Technology
Bengaluru-560056

Dr. AMBEDKAR INSTITUTE OF TECHNOLOGY

(An autonomous Institution, Aided by Govt. Of Karnataka, Affiliated to VTU, Accredited by NAAC with A Grade)

Department of Electrical and Electronics Engineering

Batch (2020-22)

SCHEME OF TEACHING AND EXAMINATION (Autonomous) for the Academic Year 2020-21

M.Tech. in POWER ELECTRONICS (EPE)

I semester

Sl. No.	Sub Code		Subject Title	Teaching Department	Teaching hours per week			Maximum Marks allotted				Examination Credits
					Lecture	Tutorial/ Seminar/ Assignment	Practical / Project	Duration in Hours	CIE	SEE	Total	
1.	PC	20EPE11	Applied Mathematics	Maths.	03	00	00	03	50	50	100	**03**
2.	PC	20EPE12	Power Semiconductor Devices and Components	EEE	03	00	00	03	50	50	100	**03**
3.	PC	20EPE13	Solid State Power Converters	EEE	03	00	00	03	50	50	100	**03**
4.	PC	20EPE14	Modeling and Simulation of Power Electronics Systems	EEE	03	00	00	03	50	50	100	**03**
5.	PE	20EPE15X	Professional Elective - I	EEE	03	00	00	03	50	50	100	**03**
6.	PE	20EPE16X	Professional Elective - II	EEE	03	00	00	03	50	50	100	**03**
7.	PC	20EPEL17	Power Electronics Laboratory – I	EEE	00	00	03	03	50	50	100	**02**
8.	PC	20EPES18	Technical Seminar*	EEE	00	04	00	00	50	00	50	**02**
9.	PC	20EPEM19	Minor Project / Industrial Visit /Field Work	EEE	00	00	06	03	50	00	50	**02**
Total					**18**	**04**	**09**	**24**	**450**	**350**	**800**	**24**

*Technical Seminar: Seminar on Advanced topics from refereed journals by each student.

Professional Elective I(Credits-03)			**Professional Elective II(Credits-03)**		
Sl .No	**Subject Code**	**Name of the Subject**	**Sl .No**	**Subject Code**	**Name of the Subject**
1	20EPE151	Embedded Systems	1	20EPE161	PWM converters and applications
2	20EPE152	Advanced Control Systems	2	20EPE162	MPPT in Solar Systems
3	20EPE153	Integration of Renewable Energy	3	20EPE163	Electric Vehicle Technology

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SCHEME OF TEACHING AND EXAMINATION (Autonomous) for the Academic year 2020-21

M.Tech. in POWER ELECTRONICS (EPE)

II semester

Sl. No.	Sub Code		Subject Title	Teaching Department	Teaching hours per week			Maximum Marks allotted				Examination Credits
					Lecture	Tutorial/ Seminar/ Assignment	Practical / Project	Duration in Hours	CIE	SEE	Total	
1.	PC	20EPE21	AC and DC Drives	EEE	03	00	00	03	50	50	100	**03**
2.	PC	20EPE22	Switched Mode Power Conversion	EEE	03	00	00	03	50	50	100	**03**
3.	PC	20EPE23	Power Electronics System Design Using Linear ICs	EEE	03	00	00	03	50	50	100	**03**
4.	PC	20EPE24	HVDC power Transmission	EEE	03	00	00	03	50	50	100	**03**
5.	PE	20EPE25X	Professional Elective - III	EEE	03	00	00	03	50	50	100	**03**
6.	PE	20EPE26X	Professional Elective - IV	EEE	03	00	00	03	50	50	100	**03**
7.	PC	20RM27	Research Methodology	MBA	02	00	00	03	50	50	100	**02**
8.	PC	20EPEL28	Power Electronics Laboratory - II	EEE	00	00	03	03	50	50	100	**02**
9.	PC	20EPEP29	Project Work Phase – I (Presentation of Synopsis)	EEE	00	00	06	03	50	00	50	**02**
Total					**20**	**00**	**09**	**27**	**450**	**400**	**850**	**24**

Professional Elective III(Credits-03)			Professional Elective IV(Credits-03)		
Sl .No	**Subject Code**	**Name of the Subject**	**Sl .No**	**Subject Code**	**Name of the Subject**
1	20EPE251	Electromagnetic Compatibility in Power Electronics	1	20EPE261	Power quality
2	20EPE252	FACTS Controllers	2	20EPE262	Uninterruptible Power Supply
3	20EPE253	Multi-Terminal DC Grids	3	20EPE263	DSP applications to drives

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Batch(2020-22)

SCHEME OF TEACHING AND EXAMINATION (Autonomous) for the Academic Year 2021-22

M.Tech. in POWER ELECTRONICS (EPE)

III semester

Sl. No.	Sub Code		Subject Title	Teaching Department	Teaching hours per week			Maximum Marks allotted				Examination Credits
					Lecture	Tutorial/ Seminar/ Assignment	Practical / Field work	Duration in Hours	CIE	SEE	Total	
1.	PC	20EPE31	Self-Study – Massive Open Online Course (MOOC)*	EEE	00	08	00	03	50	50	100	**03**
2.	PC	20EPEI32	Internship#	EEE	00	00	16	03	50	50	100	**08**
3.	PC	20EPES33	Technical Seminar	EEE	00	04	00	00	50	00	50	**02**
4.	PC	20EPEP34	Evaluation of Project Work Phase I	EEE	00	00	12	00	50	50	100	**07**
Total					**00**	**12**	**28**	**06**	**200**	**150**	**350**	**20**

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Department of Electrical and Electronics Engineering

Batch(2020-22)

SCHEME OF TEACHING AND EXAMINATION (Autonomous) for the Academic Year 2020-21

M.Tech. in POWER ELECTRONICS (EPE)

IV semester

Sl. No.	Sub Code		Subject Title	Teaching Department	Teaching hours per week			Maximum Marks allotted				Examination Credits
					Lecture	Tutorial/ Seminar/ Assignment	Practical / Field work	Duration in Hours	CIE	SEE	Total	
1.	PC	20EPEP41	Project Work Phase II – Midterm Internal Evaluation	EEE	00	00	00	00	100	00	100	**02**
2.	PC	20EPEP42	Project work evaluation and viva voce	EEE	00	00	00	03	100	100	200	**18**
Total					**00**	**00**	**00**	**03**	**200**	**100**	**300**	**20**

Subject Title : APPLIED MATHEMATICS

Sub.Code:20EPE11	No. of Credits:03=03:0:0 (L - T – P)	No. of Lecture Hours/Week : 04
Exam Duration:03 Hrs	CIE+Asmt+SS+GA+SEE=30+10+5+5+50=100	Total No.of Contact Hours:52

Course Learning Objectives:

1. The objectives of this course is to acquaint the students with principles of advanced mathematics through linear algebra, transform methods for differential equations, calculus of variations and linear and non-linear programming, that serve as an essential tool for applications of electrical engineering sciences..

Unit No	Syllabus Contents	No.of Hours	Blooms Taxnomy level.
1	**Numerical Methods:** Solution of algebraic and transcendental equations- iterative methods based on second degree equation – Muller method (no derivation), Chebyshev method. Fixed point iteration method (first order), acceleration of convergence- Δ^2- Aitken's method. System of non-linear equations – Newton-Raphson method. TEXT 2. Reference Book 1	08	L1,L2,L3.
2	**Numerical Solution of Partial Differential Equations**: Classification of second order equations, parabolic equations- solution of one dimensional heat equation, explicit method, Crank-Nicolson method. Hyperbolic equations- solution of one dimensional wave equation. TEXT 2. Reference Book 1	09	L1,L2,L3.
3	**Linear Algebra I:** Vector spaces, linear dependent, independence, basis and dimension, elementary properties, examples. Linear Transformations: Definition, properties, range and null space,TEXT 1 . Reference Book 3	08	L1,L2,L3.
4	**LinearAlgebra-II** Computation of Eigen values and Eigen vectors of real symmetric matrices-Jacobian and Given's method. **Interpolation:** Hermite interpolation, spline interpolation. TEXT 1 and TEXT 2. Reference Book 3	07	L1,L2,L3,L4
5	**Optimization**: Linear programming- formulation of the problem, graphical method, general linear programming problem and simplex method. TEXT 1 and TEXT 2. Reference Book 1	07	L1,L2,L3,L4

Note 1: Unit 1 to 5 will have internal choice

Note2:
1. Student has to submit one assignment per unit and is evaluated for 10 marks.

2. Group Activity for 5 Marks has to be evaluated through PPT Presentation/ Subject Quiz/Project and 5 marks for subject seminar

Note:3 Out of 5 Units, Unit 5 is a Webinar unit conducted through Google Classroom/Zoom/Cisco Webex etc. and will be delivered by subject faculty

Course Outcomes:

CO1	Employ numerical techniques in order to achieve more accurate values in the computation of roots of algebraic and non-linear equations.
CO2	Utilize analytical and numerical schemes to solve partial differential equations applicable to engineering problems.
CO3	Understand vector spaces, basis, linear transformations and the process of obtaining matrix of linear transformations arising in magnification and rotation of images
CO4	Apply standard iterative methods to compute eigenvalues and solve ordinary differential equations
CO5	Employ linear and non-linear programming techniques in simulation of network systems and optimization of electrical circuits.

Text Books.

1. **Linear Algebra and its Applications** - David C.Lay et al, Pearson, 5th Edition,2015
2. **Numerical methods in Engineering and Science (with C, C++ & MATLAB)-** B.S.Grewal, Khanna Publishers, 2014
3. **Graph Theory with Applications to Engineering and Computer Science**- NarsinghDeo, PHI, 2012

Reference Text Books.

1. **Numerical Methods for Scientific and Engineering Computation -** M. K. Jain et al **,** New Age International **,** 9th Edition, 2014
2. **Higher Engineering Mathematics -** B.S. Grewal, Khanna Publishers, 43rdEdition,2015
3. **Linear Algebra-** K.Hoffman et al, PHI, 2011

Subject Title : POWER SEMICONDUCTOR DEVICES AND COMPONENTS

Sub.Code:20EPE12	No. of Credits:03=03:0:0 (L - T – P)	No. of Lecture Hours/Week : 03
Exam Duration:03 Hrs	CIE+Asmt+SS+GA+SEE=30+10+5+5+50=100	Total No.of Contact Hours:39

Course Learning Objectives:

1. To analyse the working of basics power semiconductor devices
2. To analyse the working of power BJT and power MOSFET
3. To analyse the working of Thyristors, GTO and IGBT
4. To identify the types of protection circuits and their applications
5. To design the magnetic components based on the applications

Unit No	Syllabus Contents	No.of Hours	Blooms Taxnomy level.
1	Basic Semiconductor Physics: Introduction, conduction processes in semiconductors pn junctions, charge control description of pn-junction operation, avalanche breakdown. Power Diodes: Introduction, Basic structure and I-V characteristics, breakdown voltage considerations, on – state losses, switching characteristics, schottky diodes. TEXT 1 and TEXT 2. Reference Book 1	08	L1,L2,L3.
2	Bipolar Junction Transistors: Introduction, vertical power transistor structures, I-V characteristics, physics of BJT operation, switching characteristics, breakdown voltages, second breakdown, on-state losses and safe operating areas. Power MOSFETs: Introduction, Basic structure, I-V characteristics, physics of device operation, switching characteristics, operating limitations and safe operating areas. TEXT 1 and TEXT 2. Reference Book 1	09	L1,L2,L3.
3	Thyristors: Introduction, basic structure, I-V characteristics, physics of device operation, switching characteristics, methods of improving di/dt and dv/dt ratings. Gate Turn-Off Thyristors: Introduction, basic structure and I-V characteristics, physics of turn-off operation, GTO switching characteristics, over current protection of GTOs. Insulated Gate Bipolar Transistors: Introduction, basic structure, I-V characteristics, physics of device operation, latch up in IGBTs, switching characteristics, device limits and SOAs. TEXT 1 and TEXT 2. Reference Book 1	08	L1,L2,L3.
4	Emerging Devices and Circuits: Introduction, power junction field effect transistors, field-controlled thyristor, JFET-based devices	07	L1,L2,L3,L4

Unit No	Syllabus Contents	No.of Hours	Blooms Taxnomy level.
	versus other power devices, MOS-controlled thyristors, power integrated circuits, new semiconductor materials for power devices. Snubber Circuits: Function and types of snubber circuits, diode snubbers, snubber circuits for thyristors, need for snubbers with transistors, turn-off snubber, overvoltage snubber, turn-on snubber, snubbers for bridge circuit configurations, GTO snubber considerations. TEXT 1 and TEXT 2. Reference Book 1		
5	Component Temperature Control and Heat Sinks: Control of semiconductor device temperatures, heat transfer by conduction, heat sinks, heat transfer by radiation and convection. Design of Magnetic Components: magnetic materials and cores, copper windings, thermal considerations, analysis of a specific inductor design, inductor design procedures, analysis of a specific transformer design, eddy currents, transformer leakage inductance, transformer design procedure, comparison of transformer and inductor sizes. TEXT 1 and TEXT 2. Reference Book 1	07	L1,L2,L3,L4

Note 1: Unit 1 to 5 will have internal choice

Note2:
1. Student has to submit one assignment per unit and is evaluated for 10 marks.
2. Group Activity for 5 Marks has to be evaluated through PPT Presentation/ Subject Quiz/Project and 5 marks for subject seminar

Note:3 Out of 5 Units, Unit 5 is a Webinar unit conducted through Google Classroom/Zoom/Cisco Webex etc and will be delivered by subject faculty

Course Outcomes:

CO1 Understand the working of various power semiconductor devices

CO2 Understand the working and applications of BJT and Power MOSFET

CO3 Understand the working and applications of Thyristors, GTO and IGBT

CO4 Modeling and simulation of devices along with protection system

CO5 Design the magnetic components based on the applications

Course Outcomes Mapping with Programme Outcomes.

Sl.No	Course Outcome	Level of Blooms Taxonomy	No. of hours of teaching	Programme Outcome										
				1	2	3	4	5	6	7	8	9	10	11
1.	CO1:	2	08		3	1	2				2		2	2
2.	CO2.	2	09	3	3	1	2				2		2	2
3.	CO3:	2	08	3	3	1	2				2		2	2
4.	CO4:	4	07	3	3	1	2				2		2	2
5.	CO5:	5	07	3	3	1	2				2		2	2
Average CO				3	3	1	2				2		2	2

Course Outcomes Mapping with Programme Specific Outcomes

Course Outcome	PSO1	PSO2	PSO3
CO1		2	2
CO2	1	2	2
CO3		2	2
CO4		2	2
CO5		2	2
Average CO	**1**	**2**	**2**

Text Books.

1 Ned Mohan, “Power Electronics Converters, Applications, and Design”, Third Edition, Wiley Publisher, 2014

2 Muhammad H. Rashid , “Power Electronics: Circuits, Devices & Applications”, 4th edition, Pearson publisher, 2014

Reference Text Books.

1 Daniel W Hart, “Power Electronics”, 2nd edition, McGraw Hill publisher, 2013

Web Links.

1 https://books.google.co.in/books/about/Fundamentals_of_Power_Semiconductor_Devi.html id=UiqrUWrYZXkC&redir_esc=y

Subject Title : **SOLID STATE POWER CONVERTERS**

Sub.Code:20EPE13 | No. of Credits:03=03:0:0 (L - T – P) | No. of Lecture Hours/Week : 03
Exam Duration:03 Hrs | CIE+Asmt+SS+SEE=30+10+05+05+50=100 | Total No.of Contact Hours:39

Course Learning Objectives:

1. To explain operating principle of various converters.
2. To control various inverters
3. To analyze and distinguish different types of inverters
4. To design different inverters and converters
5. To solve problems on different inverters

Unit No	Syllabus Contents	No.of Hours	Blooms Taxnomy level.
1	Line Commutated Converters: Phase control, single phase semi-converter & fully controlled converter, three phase semi controlled & fully controlled converter, dual converters, effect of source inductance, single phase series converters, design of converter circuits. TEXT 1 and TEXT 2.	8	L1,L2, L3,L4
2	Inverters: Principle of operation, performance parameters, single phase bridge inverters and three phase inverters. Current source inverter, comparison between VSI & CSI, series resonant inverters.TEXT 1 and TEXT3	7	L1,L2,L3,L4
3	Voltage Control of Inverters: Single/multiple, pulse/SPWM/ modified SPWM methods, voltage control of three phase inverter, SPWM/third harmonic PWM, harmonic reduction. TEXT 1 and TEXT 2.	8	L1,L2,L3
4	Multilevel Inverters: Introduction, types, diode clamped multi-level inverters, features & applications. Capacitor clamped multilevel inverter, cascaded H-bridge multilevel inverter. TEXT 1 and TEXT 2	8	L1,L2,L3
5	DC-DC Converters: Principle of operation, analysis of step-down and step-up converters, Introduction to derived converters; transformer models, design of DC-DC Converters. TEXT 1 and **Reference 1**	8	L1,L2,L3,L4

Note 1: Unit 1 to 5 will have internal choice

Note 2: Student has to submit one assignment per unit and is evaluated for 10 marks

Note:3 Out of 5 Units, Unit 1 is a Webinar unit conducted through Google Classroom/Zoom/Cisco Webex etc and will be delivered by subject faculty.

Course Outcomes:

CO1 To explain operating principle of various converters.
CO2 To perform controlling of various inverters.

CO3 To Analyze and distinguish different types of converters.
CO4 To design different inverters and converters.
CO5 To Solve problems on different converters.

Course Outcomes Mapping with Programme Outcomes.

Sl.No	Course Outcome	Level of Blooms Taxonomy	No. of hours of teaching	Programme Outcome										
				1	2	3	4	5	6	7	8	9	10	11
1.	CO1:	L1,L2	8	3	1	1								
2.	CO2.	L1,L2,L4	7	1	3	1								
3.	CO3:	L2,L4	8	1	3	1								
4.	CO4:	L2,L4	8	1	1	3	1							
5.	CO5:	L2,L4	8		1	3								
Average CO				2	2	2	1							

Course Outcomes Mapping with Programme Specific Outcomes

Course Outcome	PSO1	PSO2	PSO3
CO1	3		
CO2	2	2	
CO3	2	2	
CO4	2	2	
CO5	2	2	
Average CO	**2**	**2**	

Text Books.

1 Ned Mohan, Tore M. Undeland, William P. Robbins"**Power Electronics Converters, Applications, and Design**", Third Edition, Wiley India Pvt. Ltd, 2011

2 Rashid M.H, "Power Electronics – Circuits Devices and Applications", 3rd Edition, Pearson, 2011.

Fang Lin Luo, Hong Ye, "**Advanced DC/AC converters- Applications to Renewable Energy**", 1st Edition, CRC2013.

Reference Text Books.

1 D K Bose"**Modern Power Electronics & AC Drives**", 1st edition, 2012

Web Links.

1 B. G. Fernandes" A course on Power Electronics" http://nptel.ac.in/courses/108101038/

2 Ramnarayan/Prof. L. Umanand "A course on Switched Mode Power Conversion") http://nptel.ac.in/courses/108108036

3 K. Gopakumar "A course on Industrial Drives – Power Electronics" http://nptel.ac.in/courses/108108077

Subject Title : MODELING AND SIMULATION OF POWER ELECTRONICS SYSTEMS

Sub.Code:20EPE14 No. of Credits:03=03:0:0 (L - T – P) No. of Lecture Hours/Week : 03
Exam Duration:03 Hrs CIE+Asmt+SS+GA+SEE=30+10+5+5+50=100 Total No.of Contact Hours:39

Course Learning Objectives:

1. Types of modeling applicable of power electronics
2. Types and need for control system
3. Control system design for converters
4. To analyze a system and to make use of the information to improve the performance
5. To analyse a system numerically

Unit No	Syllabus Contents	No.of Hours	Blooms Taxnomy level.
1	Computer Simulation of Power Electronic Converters and Systems: introduction, challenges in computer simulation, simulation process, mechanics of simulation, solution techniques for time-domain analysis, widely used, circuit-oriented simulators, equation solvers. Modelling of Systems: input-output relations, differential equations and linearization, state space representation, transfer function representation, block diagrams, circuit averaging, bond graphs, space vector modelling TEXT 1 and TEXT 2. Reference Book 1	10	L1,L2,L3.
2	Control System Essentials: control system basics, control principles, state - space method, bode diagram method, root locus method, state space method. TEXT 1 and TEXT 2. Reference Book 1	07	L1,L2,L3.
3	Digital Controller Design: controller design techniques, PID controller, full state feedback, regulator design by pole placement, estimation design, tracker: controller design, controlling voltage, controlling current, control of induction motor. TEXT 1 and TEXT 2. Reference Book 1	07	L1,L2,L3.
4	Optimal and Robust Controller Design: least squares principle, quadratic forms, minimum energy principle, least square solution, weighted least squares, recursive least squares, optimal control: linear quadratic, induction motor example, robust controller design. TEXT 1 and TEXT 2. Reference Book 1	07	L1,L2,L3,L4
5	Discrete Computation Essentials: numeric formats, tracking the base point in the fixed point system, normalization and scaling, arithmetic algorithms. TEXT 1 and TEXT 2. Reference Book 1	08	L1,L2,L3,L4

Note 1: Unit 1 to 5 will have internal choice

Note2: Student has to submit one assignment per unit and is evaluated for 10 marks Group Activity for 5 Marks has to be evaluated through PPT Presentation/ Subject Quiz/Project and 5 marks for subject seminar

Note:3 Out of 5 Units, Unit3is a Webinar unit conducted through Google Classroom/Zoom/Cisco Webex etc and will be delivered by subject faculty

Course Outcomes:

CO1 Understand the types of modeling applicable of power electronics
CO2 Understand the types and need for control systems
CO3 Design the control system for converters
CO4 Modelling and simulation of devices along with protection system
CO5 Verify a system analytically

Course Outcomes Mapping with Programme Outcomes.

Sl.No	Course Outcome	Level of Blooms Taxonomy	No. of hours of teaching	Programme Outcome										
				1	2	3	4	5	6	7	8	9	10	11
1.	CO1:	2	10		3	1	2				2		2	
2.	CO2.	2	07	1	3	1	2				2		2	3
3.	CO3:	4	07	1	3	1	2				2		2	3
4.	CO4:	4	07	1	3	1	2				2		2	3
5.	CO5:	4	08	1	3	1	2				2		2	3
Average CO				1	3	1	2				2		2	3

Course Outcomes Mapping with Programme Specific Outcomes

Course Outcome	PSO1	PSO2	PSO3
CO1		1	2
CO2		2	2
CO3	1	2	2
CO4	2	2	2
CO5	2	2	2
Average CO	**2**	**2**	**2**

Text Books.

1 Ned Mohan, “Power Electronics Converters, Applications, and Design”, Third Edition, Wiley Publisher, 2014
2 L. Umanand, “Power Electronics Essentials and Applications”, 1stedition, Pearson publisher, 2014

Reference Text Books.

1 M. Godoy Simoes, Felix A. Farret, “Modeling Power Electronics and Interfacing Energy Conversion Systems”, 1stedition, Wiley publisher, 2016

Web Links.

1 https://vtechworks.lib.vt.edu/handle/10919/31026
2 https://ieeexplore.ieee.org/document/931486

Subject Title : EMBEDDED SYSTEMS

Sub.Code:20EPE151	No. of Credits:03=0:0:0 (L - T – P)	No. of Lecture Hours/Week : 03
Exam Duration:03 Hrs	CIE+Asmt+SS+GA+SEE=30+10+5+5+50=100	Total No.of Contact Hours:39

Course Learning Objectives:

1 Describe the functional blocks of a typical embedded system.

2 Describe the fundamental issues involved in hardware, software co-designs, embedded hardware and firmware, design and development approaches.

3 Embedded system architecture and memory organization.

4 The interprocess communication, modeling, devices and communication buses.

5 Explain the fundamentals of real time operating systems and latest trends in ES domain and use it to the present need.

Unit No	Syllabus Contents	No.of Hours	Blooms Taxnomy level.
1	**Introduction to Embedded Systems:** embedded systems, processor embedded into a system, embedded hardware units and devices in a system, embedded software in a system, examples of embedded systems, embedded systems – on –chip (soc) and use of VLSI circuit design technology, design process and design examples, Communication Interfaces, classification of embedded systems, skill required for an embedded system designer. -Write a program to toggle all the led to port and with some time delay using ARM7. TEXT 1 and TEXT 2. Reference Book 1	07	L1,L2
2	**Processor Architecture and Memory Organisation:** introduction to advanced architecture, processor and memory organization, performance metrics, memory – types, memory – maps and addresses, processor selection, memory selection, Memory Management of External Memory, Board Memory and performance Basic Steps involved in PCB design. -Write a program to interface 4*4 matrix keypad with ARM7. TEXT 1 and TEXT 2. Reference Book 1	08	L1,L2,L3.
3	**Devices and Communication Buses, Interrupt Services:** IO types and examples, serial communication devices, parallel device ports, sophisticated interfacing features in device ports, wireless devices, timer and counting devices, watchdog timer, real time clock **Device Drivers and Interrupts Service Mechanisms:** Programmed – I/O busy – wait approach without interrupt service mechanism, ISR concept, interrupt sources, interrupt servicing mechanism, direct memory access.	08	L1,L2,L3.

	-Write a program to verify Timer operation in different modes TEXT 1 and TEXT 2. Reference Book 3		
4	**Program Modeling Concepts:** Program models, DFG models, state machine programming models for event – controlled program flow. **Interprocess Communication and Synchronization of Processes, Threads and Tasks:** multiple processes in an application, multiple threads in an application, tasks, task status, task and data, clear – cut dissention between functions, ISRS and tasks by their characteristics, concept of semaphores. -Write a program to interface Stepper motor with ARM7 TEXT 1 and TEXT 2. Reference Book 1	08	L1,L2,L3,L4
5	**Real-Time Operating Systems:** OS services, process management, timer functions, event functions, memory management, device, file and, real – time operating systems, basic design using an RTOS, RTOS task scheduling models, interrupt latency and response of the task as performance metrics, Task Synchronization, Multiprocessing and Multitasking. OS security issues. - Write a program for interfacing of DC motor with ARM7 TEXT 1 and TEXT 2. Reference Book 2	08	L1,L2,L3,L4

Note 1: Unit 1 to 5 will have internal choice

Note2: Two assignments are evaluated for 10 marks: Assignment -1 Two assignments are evaluated for 5 marks: Assignment -1 from Units 1 and 2. Assignment -2 from Units 3, 4 and 5

Group Activity for 5 Marks has to be evaluated through PPT Presentation/ Subject Quiz/Project and 5 marks for subject seminar

Note:3 Out of 5 Units, Unit 2 is a Webinar unit and will be delivered by subject faculty.

Course Outcomes:

CO1 Understand the concept of embedded system.

CO2 Analyse the embedded system architecture and memory organization.

CO3 Describe the differences between the general computing system and the embedded system, also recognize the classification of embedded systems.

CO4 Analyse Device Drivers and Interrupts Service Mechanisms

CO5 Design real time embedded systems using the concepts of RTOS and Analyse various real time applications of embedded system design.

Course Outcomes Mapping with Programme Outcomes.

Sl.No	Course Outcome	Level of Blooms Taxonomy	No. of hours of teaching	Programme Outcome										
				1	2	3	4	5	6	7	8	9	10	11
1.	CO1	**1**	**07**		**2**	**3**	**2**	**3**			**2**			

2.	CO2	**4**	**08**		**3**	**3**	**3**	**3**	**3**		**2**	**1**	**2**	**2**
3.	CO3	**2**	**08**		**3**	**3**	**2**	**3**			**2**	**1**	**3**	**1**
4.	CO4	**4**	**08**		**3**	**3**	**2**	**3**	**2**	**2**	**2**	**1**	**2**	**3**
5.	CO5	**5**	**08**		**3**	**3**	**2**	**3**	**3**	**3**	**2**		**2**	**2**
Average CO					**3**	**3**	**2**	**3**	**3**	**3**	**2**	**1**	**2**	**2**

Course Outcomes Mapping with Programme Specific Outcomes

Course Outcome	PSO1	PSO2	PSO3
CO1	2	2	1
CO2	1	2	
CO3	3	1	1
CO4	3	1	1
CO5	3	2	
Average CO	2	2	1

Text Books.

1. Raj Kamal, "Embedded Systems: Architecture, Programming and Design", Second Edition, McGraw Hill, 2014
2. Frank Vahid/Tony Givargis, "A Unified Hardware/Software Introduction, Wiley student edition 2002.

Reference Text Books.

1. Michael J. Pont, "Embedded C", 2nd Edition, Pearson Education, 2008
2. Nigel Gardner, "The Microchip PIC in CCS C", 2nd Revision Edition, Ccs Inc, 2002
3. Embedded Software Premier. Simon David, Addison Wessly 2000

Web Links.

1. Motorola and Intel Manuals
2. www.nptel.com

Subject Title : ADVANCED CONTROL SYSTEMS

Sub.Code:20EPE152	No. of Credits:03=03:0:0 (L - T – P)	No. of Lecture Hours/Week 03
Exam Duration:03 Hrs	CIE+Asmt+GA+SEE=40+5+5+50=100	Total No .of Contact Hours:39

Course Learning Objectives:

1. To explain the concepts of basic and digital control system for the real time analysis and design of control systems
2. The Modeling of Digital Control Systems.
3. To explain and apply concepts of state variables analysis..
4. The Optimization of the control parameters using different optimization techniques.
5. To study and analyze nonlinear systems.

Unit No	Syllabus Contents	No.of Hours	Blooms Taxnomy level.
1	Digital Control: Control System Terminology, Need of Digital control, Configurations of the Basic Digital Control Scheme, Principle of Signal Conversion, Basic Discrete – Time Signals, Time Domain Models for Discrete – Time Systems, The z – Transform, Transfer Function Models, Frequency Response, Stability on the z – Plane and Jury Stability Criterion, Sample and Hold Systems, Sampled Spectra and Aliasing, Reconstruction of Analog Signals, Practical Aspects of the choice of Sampling Rate, Principle of Discretization. TEXT 1 and TEXT 2. Reference Book	08	L1,L2,L3,L4
2	Models of Digital Control Devices and Systems: Introduction, z–Domain Description of Sampled Continuous – time Plants, z – Domain Description of Samples with Dead – Time, Implementation of Digital Controllers, Tunable PID Controllers, Digital Temperature and Position Control Systems, Stepping Motors and their Control. TEXT 1 and TEXT 2. Reference Book	08	L1,L2,L3,L4
3	State Variable Analysis of Digital Control Systems: Introduction, State Description of Digital Processors, State Description of Sampled continuous – Time Plants, State Description of Systems with Dead Time, Solution of State Difference Equations, Controllability and Observability, Multivariable Systems. TEXT 1 and TEXT 2. Reference Book	06	L1,L2,L3,L4
4	Quadratic Optimal Control: Introduction, The Concept of Lyapunov Stability, Lyapunov Functions for Linear Systems, Parameter Optimization and Optimal Control Problems, Quadratic Performance Index, Control Configurations, Optimal State Regulator, Optimal Digital Control Systems, Constrained State Feedback Control. TEXT 1 and TEXT 2. Reference Book	08	L1,L2,L3,L4

5	Nonlinear System Analysis: Introduction, Common nonlinear System Behaviours, Common nonlinearities in Control Systems, Describing Function Fundamentals, Describing Function of Common nonlinearities, Stability Analysis by the Describing Function Method, Concept of Phase Plane Analysis, Construction of Phase Portraits, System Analysis on the Phase Plane, Simple Variable Structure Systems, Lyapunov Stability Definitions, Lyapunov Stability Theorems, Lyapunov Functions for Nonlinear Systems TEXT 1 and TEXT 2. Reference Book	09	L1,L2,L3,L4

Note 1: Unit 1 to 5 will have internal choice

Note2: Two assignments are evaluated for 5 marks: Assignment -1 from Units 1 and 2. Assignment -2 from Units 3, 4 and 5

Group Activity for 5 Marks has to be evaluated through PPT Presentation/ Subject Quiz/ Project/Seminar.

Note:3 Out of 5 Units, Unit 5 is a Webinar unit conducted through Google Classroom/Zoom/Cisco WebEx etc. and will be delivered by subject faculty

Course Outcomes:

CO1 Analyze the Digital Control Systems.

CO2 Understand the modelling of Digital Control devices and systems.

CO3 Understand the fundamentals of state variables, linear and nonlinear systems.

CO4 Optimize the control parameters using different optimization techniques.

CO5 Understand and analyse the nonlinear systems

Course Outcomes Mapping with Programme Outcomes.

Sl.No	Course Outcome	Level of Blooms Taxonomy	No. of hours of teaching	Programme Outcome										
				1	2	3	4	5	6	7	8	9	10	11
1.	CO1:.	**4**	**10**	**3**	**3**	**3**		**2**			**2**	**2**	**2**	
2.	CO2.	**2**	**10**	**3**	**3**	**3**		**2**			**2**	**2**	**2**	
3.	CO3:	**2**	**12**	**3**	**3**	**3**		**2**			**2**	**2**	**2**	
4.	CO4:	**4**	**12**	**3**	**3**	**3**		**2**			**2**	**2**	**2**	
5.	CO5:	**4**	**8**	**3**	**3**	**3**		**2**			**2**	**2**	**2**	
Average CO				**3**	**3**	**3**		**2**			**2**	**2**	**2**	

Course Outcomes Mapping with Programme System Outcomes.

Course Outcome	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	1
CO2	3	3	1
CO3	3	3	1
CO4	3	3	1
CO5	3	3	1
Average CO	**3**	**3**	**1**

Text Books.

1. M Gopal, "Digital Control and State Variable Methods (Conventional and Intelligent Control Systems)", 3rd Edition, McGraw Hill, 2008
2. Katsuhiko Ogata, "Modern Control Engineering", 5th Edition, Prentice Hall India, 1997

Reference Text Books.

1. Benjamin C Kuo, "Digital Control Systems", 2nd edition, Oxford University Press, 2007
2. Katsuhiko Ogata, "State Space Analysis of Control Systems", 5th edition PHI, 1997

Web Links.

1. https://www.researchgate.net/publication/331258428_Advanced_Control_Systems_Engineering_Tutorial_One
2. https://nptel.ac.in/courses/108/103/108103007/
3. https://www.electronics-tutorial.net/control-systems/
4. http://www.ent.mrt.ac.lk/~rohan/teaching/EN5001/Reading/DORFCH1.pdf
5. https://ecetutorials.com/control-systems/

Subject Title : INTEGRATION OF RENEWABLE ENERGY

Sub.Code:20EPE153 No. of Credits:03=03:0:0 (L - T – P) No. of Lecture Hours/Week : 03

Exam Hrs Duration:03	CIE+Asmt+SS+GA+SEE=30+10+05+05+50=100	Total No.of Contact Hours:39

Course Learning Objectives:

1 Understand the stand alone and grid connected renewable energy systems.
2 Analyze to design power converters for renewable energy applications.
3 Study and comprehend the various operating modes of wind generators and solar energy systems.
4 Learn to integrategrid with renewable energy systems
5 Understand the principle of tracking maximum power in renewable energy systems.

Unit No	Syllabus Contents	No.of Hours	Blooms Taxnomy level.
1	Introduction: Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (Cost-GHG Emission) - qualitative study of different renewable energy resources ocean, biomass, hydrogen energy systems: operating principles and characteristics of: solar PV fuel cells. TEXT 1 and TEXT 2	8	L1,L2
2	Electrical Machines for Renewable Energy Conversion: Review of reference theory fundamentals-principle of operation and analysis: IG, PMSG, SCIG and DFIG. TEXT 1 and TEXT 2	7	L3,L4
3	Power Converters: Solar: Block diagram of solar photo voltaic system: line commutated converters (inversion mode) - Boost and buck-boost converters- selection of inverter. Wind: Three phase AC voltage controllers- AC-DC-AC converters: uncontrolled rectifiers, PWM Inverter. TEXT 1 and TEXT2	9	L2, L3
4	Analysis of Wind and PV Systems: Standalone operation of fixed and variable speed wind energy conversion systems and solar system-Grid connection Issues -Grid integrated PMSG and SCIG Based WECS-Grid Integrated solar system. TEXT 1 and TEXT 2. Reference Book 1	8	L2,L3,L4
5	Hybrid Renewable Energy Systems: Need for hybrid systems- range and type of hybrid systems- case studies of wind-PV maximum power point tracking (MPPT). TEXT 1 and TEXT 2. Reference Book 2	8	L2,L3,L4

Note 1: Unit 1 to 5 will have internal choice

Note2: Two assignments are evaluated for10marks: Assignment -1 from Units 1 and 2. Assignment -2 from Units 3, 4 and 5.
b) Group Activity for 5 Marks has to be evaluated through PPT Presentation/ Subject Quiz/Project/Seminar.
c) Subject Seminar for 5 Marks

Note:**3** Out of 5 Units, Unit4 is a Webinar unit conducted through Google Classroom/ Zoom/Cisco-Web ex.., and will be delivered by subject faculty.

Course Outcomes:

CO1 Understand the environmental impacts of conventional electric energy conversion systems and Identify different renewable energy systems.

CO2 Analyze different electrical machines for renewable energy operation.

CO3 Justify different Power converters for renewable energy applications.

CO4 Discuss grid integration of renewable systems.

CO5 Describe the hybrid systems to track maximum power.

Course Outcomes Mapping with Programme Outcomes.

Sl.No	Course Outcome	Level of Blooms Taxonomy	No. of hours of teaching	Programme Outcome											
				1	2	3	4	5	6	7	8	9	10	11	12
1.	CO1	**2**	**10**		**3**	**1**	**2**				**2**		**2**		**2**
2.	CO2	**2**	**10**	**3**	**3**	**1**	**2**				**2**		**2**		**2**
3.	CO3	**2**	**12**	**3**	**3**	**1**	**2**				**2**		**2**		**2**
4.	CO4	**4**	**12**	**3**	**3**	**1**	**2**				**2**		**2**		**2**
5.	CO5	**5**	**8**	**3**	**3**	**1**	**2**				**2**		**2**		**2**
Average COs				**3**	**3**	**1**	**2**				**2**		**2**		**2**

Course Outcomes Mapping with Programme Outcomes.

Course Outcome	PSO1	PSO2	PSO3
CO1	2	2	3
CO2	2	2	2
CO3	3	3	3
CO4	3	3	3
CO5	3	3	3
Average COs	3	3	3

Text Books.

1 B.H.Khan,Non-conventional Energy sources, Tata McGraw-Hill Publishing Company,2nd Edition, 2009, New Delhi.

2 Rai. G.D., Khanna ,Solar energy utilization, publisher, 1993

3 S.N. Bhadra, D. Kastha, & S. Banerjee, Wind Electrical Systems, Oxford University Press, 2009

Reference Text Books.

1 Gray, L. Johnson, Wind energy system, , Prentice hall inc., 1995. .

2 Rai. G.D, Non conventional energy sources, Khanna publishers, 1993.

3 Rashid .M. H, Power electronics Hand book, . Academic press, 2001.

Web Links.

1 Prof. L Umanand , IISc Bangalore , "Design and Simulation of Power conversion using open source tools"| http://nptel.ac.in / noc / courses/108

2 Prof. L Umanand, IISc Bangalore , "PV module in SPICE" - Videos | View - ENGGtalks, https://www.youtube.com/watch?v=Z2C28OXu4xA

3 Abhijt Kshirsagar, IIT, Dharwad , "Simulation toolkit using gEDA and ngSPICE for Digital Controller Design Course." https://sites.google.com / umn.edu/ akshirsa

4. M B Patil, IIT, Bombay, "Sequal App for classroom Teaching." https;//www.ee.iitb.ac.in / ~sequel / sequel_app.html

Subject Title : PWM CONVERTERS AND APPLICATIONS

Sub.Code:20EPE161	No. of Credits:03=03:0:0 (L - T – P)	No. of Lecture Hours/Week : 03
Exam Duration:03 Hrs	CIE+Asmt+SS+GA+SEE=30+10+5+5+50=100	Total No.of Contact Hours:39

Course Learning Objectives:

1 AC/DC and DC/AC Power Conversion
2 Different PWM Techniques
3 Computation of switching Losses
4 Dynamic Modeling of PWM converters
5 Different compensation techniques

Unit No	Syllabus Contents	No.of Hours	Blooms Taxnomy level.
1	AC/DC and DC/AC Power Conversion: Overview of applications of voltage source converters. TEXT 1 and TEXT 2. Reference Book 1	08	L1,L2,L3.
2	PWM Techniques: Pulse modulation techniques for I – phase bridges, bus clamping PWM, space vector based PWM, advanced PWM techniques. TEXT 1 and TEXT 2. Reference Book 1	08	L1,L2,L3.
3	Loss Calculations: Practical devices in converters, calculation of switching and conduction losses, compensation for dead time and DC voltage regulation. TEXT 1 and TEXT 2. Reference Book 1	08	L1,L2,L3.
4	Modelling: Dynamic model of PWM converters; constant V/F induction motor drives; estimation of current ripple and torque ripple in inverter fed drives. TEXT 1 and TEXT 2. Reference Book 1	08	L1,L2,L3,L4
5	Converters with Compensation: Line-side converters with power factor compensation, reactive power compensation, harmonic current compensation TEXT 1 and TEXT 2. Reference Book 1	07	L1,L2,L3

Note 1: Unit 1 to 5 will have internal choice

Note2: Student has to submit one assignment per unit and is evaluated for 10 marks. Group Activity for 5 Marks has to be evaluated through PPT Presentation/ Subject Quiz/ Project and 5 marks for subject seminar

Note:3 Out of 5 Units, Unit 5 is a Webinar unit conducted through Google Classroom/Zoom/Cisco Webex etc and will be delivered by subject faculty

Course Outcomes:

CO1 Explain the applications of AC/DC and DC/AC Power Conversion
CO2 Analyse different PWM Techniques
CO3 Compute switching and conduction losses

CO4	Implement dynamic modeling of PWM converters
CO5	Discuss different compensation techniques

Course Outcomes Mapping with Programme Outcomes.

Sl.No	Course Outcome	Level of Blooms Taxonomy	No. of hours of teaching	Programme Outcome										
				1	2	3	4	5	6	7	8	9	10	11
1.	CO1:	2	08		2	1	2				2			2
2.	CO2.	2	08	3	3	1	2				2		2	2
3.	CO3:	2	08	3	2	1	2				2		2	
4.	CO4:	3	08	3	3	1	2				2		2	2
5.	CO5:	2	07	3	3	1	2				2	2	2	
Average CO				3	3	1	2				2	1	2	2

Course Outcomes Mapping with Programme Specific Outcomes

Course Outcome	PSO1	PSO2	PSO3
CO1		2	2
CO2		2	2
CO3	2	2	2
CO4	3	2	2
CO5		2	2
Average CO	1	2	2

Text Books.

1 Mohan, Undeland and Robbins, "Power Electronics: Converter, Applications and Design", Third Edition, Wiley Publisher, 2011

2 Erickson RW, "Fundamentals of Power Electronics", 1st edition, Chapman Hall, 1997

Reference Text Books.

1 Joseph Vithyathil, "Power Electronics- Principles and Applications", 1st edition, TMH, 2011

Web Links.

1 https://onlinelibrary.wiley.com/doi/book/10.1002/9781118886953

2 https://books.google.co.in/books/about/Power_Electronic_Converters.html?id=5vTtWUOn60AC&redir_esc=y

Subject Title : MPPT IN SOLAR SYSTEMS

Sub.Code:20EPE162	No. of Credits:03=03:0:0 (L - T – P)	No. of Lecture Hours/Week : 03
Exam Duration:03 Hrs	CIE+Asmt+SS+GA+SEE=30+10+5+5+50=100	Total No.of Contact Hours:39

Course Learning Objectives:

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

Unit No	Syllabus Contents	No.of Hours	Blooms Taxnomy level.
1	PV Modelling: 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 Modelling 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 TEXT 1 and TEXT 2. Reference Book1	08	L1,L2,L3.
2	Maximum Power Point Tracking (continued): Improvements of the P&O Algorithm, Evolution of the Perturbative Method, PV MPPT via Output Parameters, MPPT Efficiency. 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. TEXT 1 and TEXT 2. Reference Book1	08	L1,L2,L3.
3	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. TEXT 1 and TEXT 2. Reference Book1	08	L1,L2,L3.
4	Distributed Maximum Power Point Tracking of Photovoltaic Arrays (continued): AC Analysis of a PV Array with DMPPT TEXT 1 and TEXT 2. Reference Book1	07	L1,L2,L3.
5	Design of High-Energy-Efficiency Power Converters for PV MPPT Applications: Introduction, Power, Energy, Efficiency, EnergyHarvesting in PV Plant Using DMPPT Power Converters, Losses in Power Converters, Losses in the Synchronous FET Switching Cells, Conduction Losses, Switching Losses TEXT 1 and TEXT 2. Reference Book 1	08	L1,L2,L3.

Note 1: Unit 1 to 5 will have internal choice

Note2: Student has to submit one assignment per unit and is evaluated for 10 marks and Group Activity for 5 Marks has to be evaluated through PPT Presentation/ Subject Quiz/Project and 5 marks for subject seminar

Note:3 Out of 5 Units, Unit 4 is a Webinar unit conducted through Google Classroom/Zoom/Cisco Webex etc and will be delivered by subject faculty

Course Outcomes:

CO1 Understand the characteristics of a PV cell and its models, equivalent circuits and circuit parameter calculations.
CO2 Understand the different methods of tracking maximum power point and distributed MPPT.
CO3 Identify the sources of noise, effect of noise on MPPT and reduction of noise
CO4 Analyse the differences between AC and DC analysis of PV array with DMPPT
CO5 Understand the use of high energy efficiency power converters for PV MPPT application.

Course Outcomes Mapping with Programme Outcomes.

Sl.No	Course Outcome	Level of Blooms Taxonomy	No. of hours of teaching	Programme Outcome										
				1	2	3	4	5	6	7	8	9	10	11
1.	CO1:	2	08		1	1	2				1		1	
2.	CO2.	2	08	2	2	1	3				2		2	2
3.	CO3:	3	08	3	3	1	2				2		2	
4.	CO4:	4	07	1	2	1	2				2		2	2
5.	CO5:	3	08	3	3	1	2				2		2	
Average CO				2	2	1	2				2		2	1

Course Outcomes Mapping with Programme Specific Outcomes

Course Outcome	**PSO1**	**PSO2**	**PSO3**
CO1	1	3	3
CO2	1	3	3
CO3	1	3	2
CO4	1	3	2
CO5	1	3	2
Average CO	1	3	2

Text Books.

1 Nicola Femia et al, "Power electronics and Control Techniques for Maximum energy harvesting in Photovoltaic systems", first Edition, IEEE press and John Wiley & Sons CRC Press, 2013
2 Kamal Kant Sharma, Satya Nand Vishwakarma, Gaziz Manzoor, "Hybrid PSD-GSA Based MPPT Algorithm for Photovoltaic System Understanding FACTS: Concepts and

Technology of Flexible AC Transmission Systems”, 1st edition, Published by Independently , 2019

Reference Text Books.

1 Kamal Kant Sharma, “Hyrid PSD-GSA Based MPPT Algorithm for Photovoltaic Systems”, 1st edition, Published by Independently, 2015

Web Links.

1 https://www.intechopen.com/books/recent-developments-in-photovoltaic-materials-and-devices/improved-performance-of-a-photovoltaic-panel-by-mppt-algorithms
2 https://www.researchgate.net/publication/317723124_Designing_and_implementation_of_maximum_power_point_trackingMPPT_solar_charge_controller

Subject Title : ELECTRIC VEHICLE TECHNOLOGY

Sub.Code:20EPE163 No. of Credits:03=03:0:0 (L - T – P) No. of Lecture Hours/Week : 03

Exam Duration:03 Hrs CIE+Asmt+SS+GA+SEE=30+10+05+05+50=100 Total No.of Contact Hours:39

Course Learning Objectives:

1 Advantages of EVs.

2 Various drive trains

3 Characteristics of various types of batteries.

4 Concept of hybrid electric vehicles

5 Emerging technology of EV's

Unit No	Syllabus Contents	No.of Hours	Blooms Taxnomy level.
1	Introduction to electric vehicles (EVs): EV advantages and impacts. EV regulations and standardization. Electric vehicle (EV) design options: EV con figurations: fixed vs. variable gearing, single- vs. multiple-motor drive, in-wheel drives. EV parameters, driving cycles and performance specifications. Choice of system voltage levels: electrical safety and protection. TEXT 1 and TEXT 2. Reference 1	8	L1,L2, L3,L4
2	Vehicle dynamics and motor drives: Road load: vehicle kinetics; effect of velocity, acceleration and grade. EV drive train and components. EV motor drive systems: DC drives, induction motor drives, switched reluctance motor drives, control strategies. TEXT 1 and TEXT 2. Reference 1	8	L1,L2,L3,L4
3	Batteries: Battery parameters, types and characteristics of EV batteries. Charging schemes. Open-circuit voltage and ampere- hour estimation. Battery load levelling TEXT 1 and TEXT 2. Reference 1	8	L1,L2,L3
4	Emerging EV technologies: Hybrid electric vehicles (HEVs): types, operating modes, torque coordination and control, generator/motor requirements. TEXT 1 and TEXT 2. Reference 1	9	L1,L2,L3
5	Fuel cell electric vehicles (FEVs): Fuel cell characteristics, hydrogen storage systems, ultra- capacitors. TEXT 1 and TEXT 2. Reference 1	6	L2,L3,L4

Note 1: Unit 1 to 5 will have internal choice

Note2: Student has to submit one assignment per unit and is evaluated for 10 marks and group activity for 5 marks and Seminar for 5 Marks

Note:3 Out of 5 Units, Unit 1is a Webinar unit conducted through Google Classroom/Zoom/Cisco Webex etc and will be delivered by subject faculty.

Course Outcomes:

CO1 Describe the configuration of a typical electric vehicle
CO2 Differentiate among different drive trains
CO3 Understand the limitations and advantages of various battery chemistries.
CO4 Develop strategies for charging various types of batteries.
CO5 Describe the various drive trains of hybrid electric vehicles.

Course Outcomes Mapping with Programme Outcomes.

Sl.No	Course Outcome	Level of Blooms Taxonomy	No. of hours of teaching	Programme Outcome										
				1	2	3	4	5	6	7	8	9	10	11
1.	CO1:	L1,L2	8	1	3	1								
2.	CO2.	L1,L2	8	1	3	1								
3.	CO3:	L1,L2	8	3	1	1								
4.	CO4:	L2,L3	9		3	1	1							
5.	CO5:	L2,L3	6	1	3	1								
Average CO				2	3	1	1							

Course Outcomes Mapping with Programme Specific Outcomes

Course Outcome	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	
CO2	2	2	
CO3	3		
CO4	2	2	
CO5	2	2	
Average CO	**2**	**2**	

Text Books.

1 C.C. Chan and K.T. Chau**"Modern Electric Vehicle Technology"**,1st edition Oxford University Press, London, 2001
2 Iqbal Husain **"Electric and Hybrid Vehicles**"1st edition New York: CRC Press, 2016.

Reference Text Books.

1. M. Ehsani, Y. Gao, S.E. Gay and A. Emadi,**Modern Electric, Hybrid Electric, and Fuel Cell Vehicles:** Fundamentals, Theory and Design,1st edition New York: CRC Press, 2004

Web Links.

1. Prof. Amit Jain"Electrical Vehicle part 1" http://nptel.ac.in/courses

Subject Title : POWER ELECTRONICS LABORATORY-I

Sub.Code:**20EPEL17**	No. of Credits:2=0:0:2(L - T – P)	No. of Lecture Hours/Week :03
Exam Duration:3 Hrs	CIE +SEE=50+50=100	Total No.of Contact Hours:30

Course Learning Objectives:

1 To conduct experiments on various converters and devices.
2 To analyse various parameters of converters.
3 To compute the performance of various converters.
4 To understand the working of controlled converters.
5 To compare dynamic characteristics of switching devices.

Expt .No	Experiments	No.of Hours	Blooms Taxnomy level.
1	Analysis of static and dynamic characteristic of MOSFET and IGBT	3	L2,L4
2	Performance of single phase fully controlled and semi-controlled converter for RL load for continuous current mode.	3	L1,L2,L3.
3	Performance of single phase fully controlled and semi-controlled converter for RL load for discontinuous current mode.	3	L1, L2, L3
4	Study of effect of source inductance on the performance of single phase fully controlled converter.	3	L1, L2, L3
5	Performance analysis of three phase fully controlled and semi-controlled converter for RL load for continuous current mode.	3	L2, L3, L4
6	Performance analysis of three phase fully controlled and semi-controlled converter for RL load for discontinuous current mode.	3	L2, L3, L4
7.	Performance analysis of single phase bridge inverter for RL load and voltage control by single pulse width modulation.	3	L2, L3, L4
8.	Performance analysis of two quadrant chopper.	3	L2, L3, L4
9	Diode clamped multilevel inverter.	3	L1, L2, L3
10	ZVS operation of a synchronous buck converter.	3	L1, L2, L3
11	*Simulation of converters using NgSpice open source.		

Note 1: Laboratory report should be submitted to the subject faculty every week and evaluation will be done on the same week only. * Experiment is for additional skill not for exam.

Course Outcomes:

CO1 To conduct experiments on various converters and devices.
CO2 To compare dynamic characteristics of switching devices.
CO3 To compute the performance of various converter.
CO4 To understand the working of controlled converters.
CO5 To analyse various parameters of converters.

Course outcomes Mapping with programme outcomes

Sl.No	Course Outcome	Level of Blooms Taxonomy	No. of hours of teaching	Programme Outcome										
				1	2	3	4	5	6	7	8	9	10	11
1.	CO1:	L1,L2	06	3		1			1					1
2.	CO2:	L2,L3	06		3	1			1					1
3.	CO3:	L2,L3	06			3			1					1
4.	CO4:	L1,L2	06	3	1									
5.	CO5:	L2,L4	06	1	3									
			Average CO	2	3	2			1					1

Course Outcomes Mapping with Programme Specific Outcomes

Course Outcome	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	
CO2	2	2	
CO3	2	2	
CO4	3		
CO5	2	2	
Average CO	2	2	

References Text Books.

1 Ned Mohan, Tore M. Undeland, William P. Robbins"**Power Electronics Converters, Applications, and Design**", Third Edition, Wiley India Pvt. Ltd, 2011

2 Rashid M.H, "Power Electronics – Circuits Devices and Applications", 3rd Edition, Pearson, 2011.

D K Bose"**Modern Power Electronics & AC Drives**", 1st edition, 2012

Web Links.

1 B. G. Fernandes" A course on Power Electronics" http://nptel.ac.in/courses/108101038/

2. K. Gopakumar "A course on Industrial Drives – Power Electronics"
http://nptel.ac.in/courses/108108077

Subject Title : TECHNICAL SEMINAR

Sub.Code:20EPES18 No. of Credits:2=0:0:2(L - T – P) No. of Lecture Hours/Week :02

Course Learning Objectives:

1 Analysing different technical problems in power electronics (PE) field

2 Applying different solution methodologies to solve problems in the PE field

3 Communicate effectively and efficiently

4 Demonstrate critical thinking.

5 Demonstrate lifelong learning.

Unit No	Seminar activity	No.of Hours	Blooms Taxonomy level.
1	**Technical Seminar**: The seminar should be on topic having practical importance and relevance with Power Electronics. The candidate has to refer peer reviewed journals for literature survey of minimum 10 papers. The same should be decided by the student and concerned guide. The candidate will deliver a talk on the topic for half an hour and an assessment will be made by the committee consisting of HOD, PG coordinator, Guide and senior faculty members of the department. The student should submit the report based on his/her survey and is required to make the presentation for evaluation. Seminar work shall be in the form of a report to be assessment submitted by the student at the end of the semester.	26	L2-L5

Note: **Evaluation of Seminar**:

1. Relevance of the seminar topic:10%
2. Literature survey-10%
3. Presentation-40%
4. Report-30%
5. Publications-10%

Course Outcomes: After successful completion of the course, the students should be able to

CO1 Analyse different technical problems in power electronics (PE) field

CO2 Apply different solution methodologies to solve problems in the PE field

CO3 Communicate effectively and efficiently

CO4 Demonstrate critical thinking.

CO5 Demonstrate lifelong learning

Course Outcomes Mapping with Programme Outcomes

Sl.No	Course Outcome	Level of Blooms Taxonomy	No. of hours of teaching	Programme Outcome			
				1	2	3	4
1.	CO1:	3		2	1		3
2.	CO2.	3		3	1	2	2
3.	CO3:	2		1	3	1	
4.	CO4:	4		3	1	2	1
5.	CO5:	4		3	1	2	1
Average CO				2	1	2	2

Course Outcomes Mapping with Programme Specific Outcomes

Course Outcome	PSO1	PSO2	PSO3
CO1	2	2	2
CO2	2	2	2
CO3	2	2	2
CO4	2	2	2
CO5	2	2	2
Average CO	2	2	2

Subject Title : MINOR PROJECT / INDUSTRIAL VISIT /FIELD WORK

Sub.Code:20EPEM19 No. of Credits:2=0:0:2(L - T – P) No. of Lecture Hours/Week :00

Course Learning Objectives:

1 Analyse the recent developments in Power Electronics and electrical engineering.

2 Summarize the recent development in technologies and inculcate the technical skills from literature survey

3 Strengthen in technical report writing skills

4 Demonstrate good presentation skills both in written and oral forms.

5 Support an individual to present before the audience group discussion.

Unit No	**Minor Project / Industrial Visit /Field Work Activity**	No.of Hours	Blooms Taxonomy level.
1	**Minor Project / Industrial Visit /Field Work:** The industrial visits/Technical visit will provide a platform for relating the academic knowledge learnt through theoretical concepts on a practical approach. The students of the class can visit different Core industries/Companies. students can participate in the arranged industrial visit/Technical visit individual candidate has to submit a detailed report about the industrial visit to the guide and PG coordinator.	26	L2-L4

Note: **Evaluation of Seminar**:

6. Relevance of the seminar topic:10%
7. Literature survey-10%
8. Presentation-40%
9. Report-30%
10. Publications-10%

Course Outcomes: After successful completion of the course, the students should be able to

CO1 Identify the filed/area for enhancement of technical knowledge

CO2 Analyze the information to provide valid conclusions with ethical principles.

CO3 Aquire the knowledge of recent technologies

CO4 Perform the talks within the stipulated time duration.

CO5 Justify the presentation and report contents individually.

Course Outcomes Mapping with Program Outcomes

Sl.No	Course Outcome	Level of Blooms Taxonomy	No. of hours of teaching	Programme Outcome			
				1	2	3	4
1.	CO1:	3		2	1		3
2.	CO2.	3		3	1	2	2
3.	CO3:	2		1	3	1	
4.	CO4:	3		3	1	2	1
5.	CO5:	5		3	1	2	1
Average CO				2	1	2	2

Course Outcomes Mapping with Programme Specific Outcomes

Course Outcome	PSO1	PSO2	PSO3
CO1	2	3	2
CO2	2	3	2
CO3	2	3	2
CO4	2	3	2
CO5	2	3	2
Average CO	2	3	2

Subject Title : AC-DC DRIVES

Sub.Code: 20EPE21 | No. of Credits:03=03:0:0 (L - T – P) | No. of Lecture Hours/Week : 03
Exam Duration:03 Hrs | CIE+Asmt+SS+GA+SEE=30+10+5+5+50=100 | Total No.of Contact Hours:39

Course Learning Objectives:

1 Different Quadrant operation of Drives..
2 The concept of DC variable speed drives.
3 Different control methods of AC drives.
4 Closed loop Control of AC Drives
5 Control Techniques using Microprocessor/Microcontroller

Unit No	Syllabus Contents	No.of Hours	Blooms Taxnomy level.
1	Electric Drives: Introduction – block diagram-classification of electrical drives--fundamental torque equation- components of load torque- steady state stability. TEXT 1 and TEXT 2. Reference Book 1	8	L1,L2,L3.
2	DC Drives: Two quadrants Drive: 1-phase and 3-phase full converter drive. Four Quadrant drive: Three- phase dual converter drive. Different braking methods and closed loop control of DC drives. TEXT 1 and TEXT 2. Reference Book 2	8	L1,L2,L3.
3	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, voltage and current source inverter fed induction motor drives, stator and rotor voltage control methods, slip energy recovery drives. TEXT 1 and TEXT 2. Reference Book 1	8	L1,L2,L3.
4	Closed Loop Control of AC Drives: Basic Principle of Vector Control, Direct & Indirect Vector control of Induction Motor, Stator voltage control, Slip regulation and Speed control of static Kramer's drive. TEXT 1 and TEXT 2. Reference Book 3	8	L1,L2,L3.
5	Microcontroller Control of Electric Drives: Introduction to Microcontroller, Timers, Interrupts, ADC and DAC, Control of DC drives using microcontroller, Microcontroller based regular sampled PWM control using three timer control and four timer control. Control of VSI-Induction motor drives using Microcontroller. TEXT 3 Reference Book 2	7	L1,L2,L3.

Note 1: Unit 1 to 5 will have internal choice

Note2: Student has to submit one assignment per unit and is evaluated for 10 marks and group activity for 5 marks and Seminar for 5 Marks

Note:3 Out of 5 Units, Unit 5 is a Webinar unit conducted through Google Classroom/Zoom/Cisco Webex etc and will be delivered by subject faculty.

Course Outcomes:

CO1 Acquainted with the knowledge of various AC/DC drives
CO2 Demonstrate the knowledge of different quadrant operation of AC/DC drives.
CO3 Demonstrate the different methods of AC drives control.
CO4 Develop the closed loop control of Electrical Drives.

CO5 Acquainted the knowledge of using microprocessor for Drive control.

Course Outcomes Mapping with Programme Outcomes.

Sl.No	Course Outcome	Level of Blooms Taxonomy	No. of hours of teaching	1	2	3	4	5	6	7	8	9	10	11
1.	CO1:.	**1,2,3**	08	**3**	**3**						**1**		**1**	
2.	CO2.	**1,2,3**	08	**3**	**3**		**2**				**1**		**1**	
3.	CO3:	**1,2**	08	**3**	**3**						**1**		**1**	
4.	CO4:	**3,4**	08	**3**	**3**		**2**							
5.	CO5:	**1,2,3**	07	**3**	**3**		**2**				**1**		**1**	
Average CO's				**3**	**3**		**2**				**1**		**1**	

Course Outcomes Mapping with Programme Specific Outcomes

Course Outcome	**PSO1**	**PSO2**	**PSO3**
CO1	3		1
CO2	3		1
CO3	3	2	1
CO4	3	2	1
CO5	3	3	1
Average CO	**3**	**2**	**1**

Text Books.

1 B K Bose , "Modern Power Electronics & AC Drives ", 2nd edition , PHI, 2011
2 R Krishnan , "Electric Motor Drives ", 2nd edition, PHI, 2010
3 IEEE Transactions on Industry Applications , "Simple Microprocessor Implementation of New Regular Sampled Harmonic Elimination PWM Techniques,", Vol 28, No.1, Jan/Feb 1992, pp.89-94

Reference Text Books.

1 Murphy JMD, Turnbull F.G., "Thyristor Control of AC Motors ", Third edition , Pergamon Press Oxford,1998, Choose an item.
2 MehrdadEhsani, YiminGaoAlinEmadi , "High Performance Control of AC Drives, Wiley 2012
3 Muhammad H. Rashid, "Power Electronics- Circuits, Devices and Applications, Pearson Prentice Hall,2010.

Web Links.

1 https://www.academia.edu/26714897/R_Krishnan_Electric_Motor_Drives_Modeling_Analysis_and_Control_2001_

2 https://www.pdfdrive.com/modern-power-electronics-and-ac-drives-e18928858.html

3 file:///C:/Users/EEE/Downloads/32_Sample_Chapter.pdf

Subject Title : SWITCHED MODE POWER CONVERSION

Sub.Code:20EPE22 No. of Credits:03=03:0:0 (L - T – P) No. of Lecture Hours/Week : 03
Exam Duration:03 Hrs CIE+Asmt+SS+GA+SEE=30+10+05+05+50=100 Total No.of Contact Hours:39

Course Learning Objectives:

1. To explain operating principle of various converters.
2. To design transformer and inductor for Dc-DC converter
3. To analyze and distinguish different power converters
4. To design different power converters.
5. To solve problems on different power converters.

Unit No	Syllabus Contents	No.of Hours	Blooms Taxnomy level.
1	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, 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, principle of operation and analysis of buck boost converter analysis, inductors current ripple and output voltage ripple, design considerations for continuous current mode operation.Buck-boost converter for discontinuous current operation. TEXT 1 and Text 2 Reference 1	8	L1,L2, L3,L4
2	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). Derived 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. TEXT 1 and Text 2 Reference 1	7	L2,L3,L4
3	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. TEXT 1 and TEXT 2.	8	L2,L3,L4
4	Control of DC-DC Converter: Modeling of DC-DC converters, power supply control, control loop stability, small signal analysis, switch transfer function, filter transfer function, PWM transfer function, Type-2 error amplifier with compensation, Type-3 error amplifier with compensation, design. TEXT 1 and TEXT 2. Reference Book 3	8	L2,L3,L4

Unit No	Syllabus Contents	No.of Hours	Blooms Taxnomy level.
5	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. Design of inductor and transformers for SMPC. TEXT 1 and TEXT 2. Reference 2	8	L2,L3,L4,L5

Note 1: Unit 1 to 5 will have internal choice

Note2: Student has to submit one assignment per unit and is evaluated for 10 marks and group activity for 5 marks and Seminar for 5 Marks

Note:3 Out of 5 Units, Unit 1is a Webinar unit conducted through Google Classroom/Zoom/Cisco Webex etc. and will be delivered by subject faculty.

Course Outcomes:

CO1 Explain operating principle of various converters.
CO2 Design transformer and inductor for Dc-DC converter.
CO3 Analyze and distinguish different power converters.
CO4 Design different power converters.
CO5 Solve problems on different power converters.

Course Outcomes Mapping with Programme Outcomes.

Sl.No	Course Outcome	Level of Blooms Taxonomy	No. of hours of teaching	Programme Outcome										
				1	2	3	4	5	6	7	8	9	10	11
1.	CO1	L1, L2	8	3	1	1								
2.	CO2	L2, L4	7		1	3								
3.	CO3	L2,L4	8		3	1	1							
4.	CO4	L2,L4	8		1	3	1							
5.	CO5	L2,L3	8		1	3								
Average CO				3	2	3	1							

Course Outcomes Mapping with Programme Specific Outcomes

Course Outcome	PSO1	PSO2	PSO3
CO1	3		
CO2	2	2	
CO3	2	2	
CO4	2	2	
CO5	2	2	1
Average CO	**2**	**2**	**1**

Text Books.

1 Daniel W Hart “Power Electronics”, First Edition, Tata McGraw Hill, 2011
2 Rashid M.H, “Power Electronics – Circuits Devices and Applications”, 3rd Edition, Pearson, 2011.

Reference Text Books.

1 D M Mitchel “DC-DC Switching Regulator Analysis -”, 1st edition, McGraw-Hill Ltd. 1988

2 Umanand L and Bhatt S R, “Design of Magnetic Components for Switched Mode Power Converters”, 1 st edition, New Age International 2001

3 Ned Mohan, Tore M. Undeland, William P. Robbins, “Power Electronics Converters, Applications, and Design”, 3rd edition, Wiley India Pvt. Ltd2010

Web Links.

1 Prof. B. G. Fernandes” A course on Power Electronics” http://nptel.ac.in/courses/108101038/

2 Prof. V. Ramnarayan/Prof. L. Umanand “A course on Switched Mode Power Conversion”) http://nptel.ac.in/courses/1081080363 Prof. K. Gopakumar “A course on Industrial Drives – Power Electronics”

Subject Title : POWER ELECTRONICS SYSTEM DESIGN USING LINEAR ICs

Sub.Code:20EPE23	No. of Credits:03=03:0:0 (L - T – P)	No. of Lecture Hours/Week : 03
Exam Duration:03 Hrs	CIE+Asmt+SS+GA+SEE=30+10+05+05+50=100	Total No.of Contact Hours:39

Course Learning Objectives:

1. Understand basic requirements of designing, measurement & protection circuits for power electronics systems using ICs.
2. Analyze various PWM ICs for controlling power electronics systems.
3. To analyze and distinguish different A/D and D/A converter circuits using ICs .
4. To design different power converters gating circuits using ICs.
5. To understand and program using PLC for power converters control.

Unit No	Syllabus Contents	No.of Hours	Blooms Taxnomy level.
1	Introduction: Measurement techniques for voltages, current, power, power factor in power electronic circuits, sensing of speed. TEXT 1 and Text 2	7	L1,L2
2	Switching Regulator Control Circuits: Introduction, isolation techniques of switching regulator systems, PWM systems. TEXT 1 and Text 2	7	L2,L3
3	Commercial PWM Control ICs and their Applications: TL 494 PWM control IC, UC 1840 programmable off line PWM controller, UC 1860 resonant mode power supply controller. Switching power supply ancillary, supervisory & peripheral circuits and components: introduction, opto couplers, self-biased techniques used in primary side of reference power supplies, soft/start in switching power supplies. TEXT 1 and TEXT 2.Reference Book 2	9	L3,L4
4	Protection of Switching power supply systems: current limit circuits, over voltage protection, AC line loss detection. Phase – Locked Loops (PLL) & Applications: PLL Design using IC:, 555 timer & its applications, analog to digital converter using IC's, digital to analog converters using ICs, implementation of different gating circuits. TEXT 1 and TEXT 2. Reference Book 3	8	L2,L3,L4
5	Programmable Logic Controllers (PLC): Basic configuration of a PLC, power converter control using PLC,IC for Switch-Mode Power Supplies: Control IC for Switch mode power supplies, IC timers as controllers for switch-mode power supplies. TEXT 1 and TEXT 2. Reference 2	8	L2,L3,L4

Note 1: Unit 1 to 5 will have internal choice

Note2: Student has to submit one assignment per unit and is evaluated for 10 marks and group activity for 5 marks and Seminar for 5 Marks

Note:3 Out of 5 Units, Unit 4 is a Webinar unit conducted through Google Classroom/ Zoom/Cisco-Web ex.., and will be delivered by subject faculty.

Course Outcomes:

CO1 Identify different measuring instruments required in Power Electronics circuits.

CO2 Explain different methods of protection & isolation required in Power Electronics circuits.
CO3 Justify different ICs available for PWM generation in Power converters.
CO4 Understand PLC programming & implement gating circuits for power converters.
CO5 **Analyse different switching power supply protection circuit.**

Course Outcomes Mapping with Programme Outcomes.

Sl. No	Course Outcome	Level of Blooms Taxonomy	No. of hours of teaching	Programme Outcome										
				1	2	3	4	5	6	7	8	9	10	11
1.	CO1	**2**	**7**		**3**	**1**	**2**				**2**		**2**	
2.	CO2	**2**	**7**	**3**	**3**	**1**	**2**				**2**		**2**	**2**
3.	CO3	**2**	**9**	**3**	**3**	**1**	**2**				**2**		**2**	**2**
4.	CO4	**4**	**8**	**3**	**3**	**1**	**2**				**2**		**2**	**2**
5.	CO5	**5**	**8**	**3**	**3**	**1**	**2**				**2**		**2**	
Average Cos				**3**	**3**	**1**	**2**				**2**		**2**	**2**

Course Outcomes Mapping with Programme Outcomes.

Course Outcomes	PSO1	PSO2	PSO3
CO1	2		
CO2		2	
CO3		2	3
CO4	3	2	
CO5	3	2	3
Average COs	3	2	3

Text Books.

1 G. K. Dubey, S. R. Doradla, A. Joshi, and R. M. K. Sinha,Thyristorised Power Controllers, 2nd Edition, New Age International, 2010.

2 Ned Mohan, Tore M. Undeland, William P. Robbins ,"Power Electronics Converters, Applications, and Design ", 3rd Edition, Wiley India Pvt. Ltd ,2010 .

Reference Text Books.

1 Unitrode application notes: http://www.smps.us/Unitrode.html

2 Switch- Mode Power Supply Design, P.R.K. Chetty, BPB Publications

3 Chryssis,, "High Frequency Switching Power Supplies", 2nd edition, MGH1989

Web Links.

1 Prof. L Umanand , Design and Simulation of Power conversion using open source tools,| IISc Bangalore

2 Prof. L Umanand, PV module in SPICE - Videos | View - ENGGtalks,IISc Bangalore

3 Abhijt Kshirsagar, Simulation toolkit using gEDA and ngSPICE for Digital Controller Design Course, IIT, Dharwad

Subject Title : HVDC POWER TRANSMISSION

Sub.Code:20EPE24	No. of Credits:03=03:0:0 (L - T – P)	No. of Lecture Hours/Week : 03
Exam Duration:03 Hrs	CIE+Asmt+SS+GA+SEE=30+10+05+05+50=100	Total No.of Contact Hours:39

Course Learning Objectives:

1 To give an introduction to DC power transmission and describe the basic components of a converter.
2 To describe the methods for compensating the reactive power demanded by the converter and the methods for simulation of HVDC systems
3 To describe the types of filters for removing harmonics and the characteristics of the system impedance resulting from AC filter designs and different methods of control of HVDC converter and system.
4 To explain the design techniques for the main components of an HVDC system.
5 To explain the protection of HVDC system and other converter configurations used for the HVDC transmission and the recent trends for HVDC applications.

Unit No	Syllabus Contents	No.of Hours	Blooms Taxnomy level.
1	HVDC Technology: Introduction, Advantages of HVDC Systems, HVDC System Costs, Overview and Organization of HVDC Systems, Review of the HVDC System Reliability, HVDC Characteristics and Economic Aspects. Power Conversion: Thyristor, 3-Phase Converter, 3-Phase Full Bridge Converter, 12-Pulse Converter. TEXT 1 and Text 2	8	L2, L3,L4
2	Harmonics of HVDC and Removal: Introduction, Determination of Resulting Harmonic Impedance, Active Power Filter. Control of HVDC Converter and System: Converter Control for an HVDC System, Commutation Failure TEXT 1 and Text 2	8	L2,L3,L4
3	Control of HVDC Converter and System (continued): HVDC Control and Design, HVDC Control Functions, Reactive Power and Voltage Stability. Interactions between AC and DC Systems: Definition of Short Circuit Ratio and Effective Short Circuit Ratio.	8	L2,L3
4	Main Circuit Design: Converter Circuit and Components, Converter Transformer, Cooling System, HVDC Overhead Line, HVDC Earth Electrodes, HVDC Cable, HVDC Telecommunications Current Sensors, HVDC Noise and Vibration. TEXT 1 and TEXT 2. Reference Book 3	8	L2,L3
5	Fault Behaviour and Protection of HVDC System: Valve Protection Functions, Protective Action of an HVDC System, Protection by Control Actions, Fault Analysis. Other Converter Configurations for HVDC Transmission: Introduction, Voltage Source Converter (VSC), CCC and CSCC HVDC System, 10.4 Multi-Terminal DC Transmission.	7	L2,L3,L4

Unit No	Syllabus Contents	No.of Hours	Blooms Taxnomy level.
	Trends for HVDC Applications: Wind Farm Technology, Modern Voltage Source Converter (VSC) HVDC Systems. TEXT 1 and TEXT 2. Reference 3		

Note 1: Unit 1 to 5 will have internal choice

Note2: Student has to submit one assignment per unit and is evaluated for 10 marks and group activity for 5 marks and Seminar for 5 Marks

Note:3 Out of 5 Units, Unit1is a Webinar unit conducted through Google Classroom/Zoom/Cisco Webex etc and will be delivered by subject faculty.

Course Outcomes:

CO1 Explain the importance of DC power transmission, the basic components of a converter and methods for compensating the reactive power.

CO2 Explain the methods for simulation of HVDC systems and its control.

CO3 Design filters for eliminating harmonics.

CO4 Explain the design techniques for the main components of an HVDC system.

CO5 Analyse the protection of HVDC system and other converter configurations used for the HVDC transmission and recent trends for HVDC applications.

Course Outcomes Mapping with Programme Outcomes.

Sl.No	Course Outcome	Level of Blooms Taxonomy	No. of hours of teaching	Programme Outcome										
				1	2	3	4	5	6	7	8	9	10	11
1.	CO1:	L1,L2	8		3	1	2				2		2	
2.	CO2	L1,L2	8	3	3	1	2				2		2	
3.	CO3	L2,L3	8	3	3	1	2				2		2	
4.	CO4	L1,L2	8	3	3	1	2				2		2	
5.	CO5	L3,L4	7	3	3	1	2				2		2	
Average CO				3	3	1	2				2		2	

Course Outcomes Mapping with Programme Specific Outcomes

Course Outcome	PSO1	PSO2	PSO3
CO1	3		
CO2	3		
CO3	2	2	
CO4	3		
CO5	2	2	
Average CO	**3**	**2**	

Text Books.

1. 1. Chan-Ki Kim et al " HVDC Transmission: Power Conversion Applications in Power Systems" Wiley, 2009

Reference Text 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.

   Vijay K Sood, "HVDC and FACTs Controllers; Applications of Static Converters in Power Systems, BSP Books Pvt. Ltd., First Indian reprint 2013.

Web Links.

Prof.S.N.Singh "High Voltage DC Transmission",http://nptel.iitm.ac.in

Subject Title : ELECTROMAGNETIC COMPATIBILITY IN POWER ELECTRONICS

Sub.Code:**20EPE251**	No. of Credits:03=03:0:0 (L - T – P)	No. of Lecture Hours/Week : 03
Exam Duration:03 Hrs	CIE+Asmt+SS+SEE=30+10+10+50=100	Total No.of Contact Hours:39

Course Learning Objectives:

1. Discover and compare the concept of electromagnetic compatibility and national and international EMC regulations, including the European Union, FCC, and U.S. Military standards
2. Explain and identify the Intrinsic noise sources, such as thermal and shot noise etc.
3. Describe, Analyse, Illustrate and decide solutions for the electromagnetic compatibility issues associated with digital circuits.
4. Discuss, Analyse, Illustrate and decide solutions for the conducted emissions on alternating current (ac) and direct current (dc) power lines, as well as EMC issues associated with switching power supplies and variable-speed motor drives.
5. Discuss, Illustrate, Electrostatic discharge protection in the design of electronic products and to focus on the importance of various approaches, which includes mechanical, electrical, and software design.

Unit No	Syllabus Contents	No.of Hours	Blooms Taxnomy level.
1	Electromagnetic Compatibility: Introduction, noise and interference, designing for electromagnetic compatibility, engineering documentation and EMC, united states' EMC regulations, FCC regulations, FCC part 15, subpart b, emissions, susceptibility, medical equipment, telecom, automotive. Canadian EMC requirements, European union's EMC requirements, emission requirements. TEXT 1 and TEXT 2 Reference Books 1 & 2	7	L1,L2,L3
2	Intrinsic Noise Sources: Thermal noise, characteristics of thermal noise, equivalent noise bandwidth, shot noise, contact noise, popcorn noise addition of noise voltages, measuring random noise, problems.TEXT 1: andTEXT 2: Reference Books: 1 & 2	7	L2,L3
3	Digital Circuit Radiation : Differential-mode radiation, loop area, loop current, radiated emission envelope, controlling differential-mode radiation board layout, cancelling loops, dithered clocks, common-mode radiation, controlling common-mode radiation, problems. TEXT 1: and TEXT 2: Reference Books: 1 & 2	7	L2,L3,L4,L5
4	Conducted Emissions: Switched-mode power supplies, common-mode emissions differential-mode emissions, DC-to-DC converters, rectifier diode noise power-line filters, common-mode filtering, differential-mode filtering. Leakage inductance, filter mounting, power supplies with integral power-line filters, high-frequency noise, primary-to-secondary common-mode coupling frequency dithering, power supply instability, magnetic field emissions, variable speed motor drives, harmonic suppression, inductive input filters active power factor correction, AC line reactors, problems. TEXT 1: and TEXT 2: Reference Books:1 & 2	9	L2,L3,L4,L5
5	Electrostatic Discharge: Static generation, inductive charging, energy storage, human body model, static discharge, decay time, ESD protection in equipment design, preventing ESD entry, metallic enclosures, input/output cable treatment, insulated enclosures,	9	L2,L3,L5

	keyboards and control panels, hardening sensitive circuits, ESD grounding, no grounded products, field-induced upset, inductive coupling, capacitive coupling. TEXT 1: and and TEXT 2: Reference Books:1 & 2		

Note 1: Unit 1 to 5 will have internal choice

Note2: Student has to submit one assignment per unit and is evaluated for 10 marks and group activity for 5 marks and Seminar for 5 Marks

Note:3 Out of 5 Units, Unit 5 is a Webinar unit conducted through Google Classroom/Zoom/Cisco WebEx etc. and will be delivered by subject faculty.

Course Outcomes:

CO1	Discover, Compare and Explain the various causes and effects of Electromagnetic interference and design systems for EMC, and various regulations governing the same.
CO2	Distinguish intrinsic noise sources and derive means of eliminating them..
CO3	Discuss, Analyse and differentiate digital circuit radiation and decide solutions.
CO4	Discuss, Analyse and decide solutions for various issues related to conducted emissions and apply to switching power supplies and variable –speed motor drives
CO5	Discuss and Illustrate the importance of ESD in the design of electronic products and software.

Course Outcomes Mapping with Programme Outcomes.

Sl.No	Course Outcome	Level of Blooms Taxonomy	No. of hours of teaching	Programme Outcome											
				1	2	3	4	5	6	7	8	9	10	11	
1.	CO1:.	**1,2**	**7**	**1**	**2**		**3**				**2**	**2**			
2.	CO2.	**2,3**	**7**	**2**	**3**	**3**	**2**				**2**	**2**			
3.	CO3:	**2,3,4,5**	**7**		**3**	**3**	**3**	**2**	**3**	**3**	**2**	**2**			
4.	CO4:	**2,3,4,5**	**9**		**3**	**3**	**2**	**2**	**2**		**3**	**2**			
5.	CO5:	**2,3,5**	**9**		**3**	**2**		**2**			**2**	**2**			
Average CO				**2**	**3**	**3**	**3**	**2**	**3**	**3**	**2**	**2**			

Course Outcomes Mapping with Programme Specific Outcomes

Course Outcome	PSO1	PSO2	PSO3
CO1	3	1	2
CO2	3	2	2
CO3	3	2	2
CO4	3	2	2
CO5	3	2	2
Average CO	**3**	**2**	**2**

Text Books.

1 H W Ott, , 1989 H W Ott, “Noise Reduction Techniques in Electronic systems” Ch, Second edition John Wiley Publisher”.

2 H W Ott, “Electromagnetic Compatibility Engineering”, Second edition, Wiley Interscience publisher, 2009

Reference Text Books.

1 Clayton R Paul, “Introduction to Electromagnetic Compatibility”, Second edition, Wiley Interscience publisher, 2006.

2 Prasad V Kodali, “Engineering Electromagnetic Compatibility”, Second edition, Wiley-Blackwell and S Chand publisher, 2006.

Web Links.

1 http://www.ofcom.org.uk/website/regulator-archives

2 www.autoemc.net

3 www.fcc.gov/engineering-technology/electromagnetic-compatibility-division/radio-frequency-safety/faq/rf-safety

Subject Title : FACTS CONTROLLERS

Sub.Code:20EPE252 | No. of Credits:03=03:0:0 (L - T – P) | No. of Lecture Hours/Week : 03
Exam Duration:03 Hrs | CIE+Asmt+SS+GA+SEE=30+10+5+5+50=100 | Total No.of Contact Hours:39

Course Learning Objectives:

1 To know the importance of compensation in transmission lines and the concepts of FACTS devices.

2 Transmission line network of power system and its control parameters

3 To illustrate the design, modeling and applications of SVC

4 To learn the operation, modes, modeling and applications of TCSC

5 To study the principle, characteristics, modeling and applications of STATCOM and SSSC

Unit No	Syllabus Contents	No.of Hours	Blooms Taxnomy level.
1	Control Mechanism: Background, electrical transmission networks, conventional control mechanisms, flexible ac transmission systems (FACTS), emerging transmission networks. Reactive-Power Control in Electrical Power Transmission Systems: Reactive power, uncompensated transmission lines, passive compensation. Principles of Conventional Reactive-Power Compensators: Introduction, synchronous condensers, the saturated reactor (SR), the thyristor-controlled reactor (TCR). TEXT 1 and TEXT 2. Reference Book 1	08	L1,L2,L3.
2	Principles of Conventional Reactive-Power Compensators (continued): The fixed capacitor–thyristor-controlled reactor (FC–TCR), The mechanically switched capacitor–thyristor-controlled reactor (MSC–TCR), The thyristor-switched capacitor (TSC), the thyristor-switched capacitor–thyristor-controlled reactor (TSC–TCR), a comparison of different SVCs. SVC Voltage Control: Introduction voltage control. TEXT 1 and TEXT 2. Reference Book 1	08	L1,L2,L3.
3	SVC Voltage Control (continued): Effect of network resonances on the controller response, the 2nd harmonic interaction between the svc and ac network, application of the SVC to series-compensated ac systems, 3rd harmonic distortion, voltage-controller design studies. TEXT 1 and TEXT 2. Reference Book 1	08	L1,L2,L3.
4	SVC Applications: Introduction, increase in steady-state power-transfer capacity, enhancement of transient stability, augmentation of power-system damping - principle of the svc auxiliary control, torque contributions of SVC controllers, effect of the power system, effect of the SVC, SVC mitigation	08	L1,L2,L3.

	of sub synchronous resonance (SSR) - principle of svc control, configuration and design of the SVC controller, rating of an SVC, prevention of voltage instability- principles of svc control- a case study, Configuration and Design of the SVC Controller, Rating of an SVC. The Thyristor-Controlled Series Capacitor (TCSC): Series compensation, the TCSC controller, operation of the TCSC, the TSSC, analysis of the TCSC, capability characteristics, harmonic performance, losses, response of the TCSC, modeling of the TCSC. TEXT 1 and TEXT 2. Reference Book 1		
5	TCSC Applications: Introduction, open-loop control, closed-loop control, improvement of the system-stability limit, enhancement of system damping, sub synchronous resonance (SSR) mitigation, voltage-collapse prevention. VSC based FACTS Controllers: Introduction, the STATCOM, the SSSC, the UPFC, comparative evaluation of different FACTS controllers. TEXT 1 and TEXT 2. Reference Book 1	07	L1,L2,L3.

Note 1: Unit 1 to 5 will have internal choice

Note2: Student has to submit one assignment per unit and is evaluated for 10 marks and group activity for 5 marks and Seminar for 5 Marks Group Activity for 5 Marks has to be evaluated through PPT Presentation/ Subject Quiz/Project and 5 marks for subject seminar

Note:3 Out of 5 Units, Unit 5 is a Webinar unit conducted through Google Classroom/Zoom/Cisco Webex etc and will be delivered by subject faculty

Course Outcomes:

CO1	Will be able to explain the basic fundamental of FACTS controllers
CO2	Will be able to summarize about Static VAR Compensators
CO3	Will be able to explain about modeling, operation and control strategies of Static series compensation-SVC
CO4	Will be able to explain the voltage source based FACTS controllers
CO5	Will be able to explain the modeling and design of Coordinating multiple FACTS controllers using control techniques

Course Outcomes Mapping with Programme Outcomes.

Sl.No	Course Outcome	Level of Blooms Taxonomy	No. of hours of teaching	Programme Outcome										
				1	2	3	4	5	6	7	8	9	10	11
1.	CO1:	2	08		2	1	2				2		2	
2.	CO2.	2	08	3	3	2	2				2		2	2

3.	CO3:	3	08	3	3	2	2				2		2	
4.	CO4:	2	08	3	3	1	2				2		2	2
5.	CO5:	4	07	2	3	1	2				2		2	
Average CO				3	3	1	2				2		2	1

Course Outcomes Mapping with Programme Specific Outcomes

Course Outcome	PSO1	PSO2	PSO3
CO1		2	2
CO2		2	2
CO3		2	2
CO4		3	3
CO5	2	2	3
Average CO	**1**	**2**	**3**

Text Books.

1 Mohan Mathur, R, Rajiv. K. Varma, "Thyristor – Based FACTS Controllers for Electrical Transmission Systems", Third Edition, IEEE press and John Wiley & Sons, 2014

2 Narain G Hingorani and L. Gyugyi, "Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems", 1st edition, Wiley India, 2017

Reference Text Books.

1 K.R Padiyar, "FACTS Controllers in Power Transmission and Distribution", 1st edition, New Age International publisher, 2007

Web Links.

1 https://books.google.co.in/books/about/Flexible_Ac_Transmission_Systems_FACTS.html?id=AqPr4JyDWg0C

2 https://onlinelibrary.wiley.com/doi/pdf/10.1002/9780470524756.fmatter

Subject Title: MULTI-TERMINAL DC GRIDS

Sub.Code:20EPE253	No. of Credits:03=03:0:0 (L - T – P)	No. of Lecture Hours/Week : 03
Exam Duration:03 Hrs	CIE+Asmt+SS+GA+SEE=30+10+5+5+50=100	Total No .of Contact Hours:39

Course Learning Objectives:

1. The fundamentals of MTDC grids, their network architectures, components and configurations.
2. Basics of voltage sourced converters and its practical applications
3. To explain modeling, simulation and analysis of AC- MTDC grids
4. To explain the concept of power sharing in MTDC grid, load flow solution and post contingency operation
5. To explain protection issues of MTDC grids, including the DC circuit breakers and fault blocking VSC systems and protection strategies

Unit No	Syllabus Contents	No.of Hours	Blooms Taxnomy level.
1	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. TEXT 1 and TEXT 2. Reference Book `	08	L1,L2,L3.
2	Voltage-Sourced Converter (VSC): Introduction, Ideal Voltage-Sourced Converter, Practical Voltage-Sourced Converter, Control, Simulation. Modelling, Analysis, and Simulation of AC–MTDC Grids: Introduction, MTDC Grid Model.TEXT 1 and TEXT 2. Reference Book 1	08	L1,L2,L3.
3	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, Transient Stability Analysis of AC–MTDC Grid. TEXT 1 and TEXT 2. Reference Book 1	08	L1,L2,L3.
4	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. TEXT 1 and TEXT 2. Reference Book 1	07	L1,L2,L3.
5	Frequency Support: Introduction, Fundamentals of Frequency Control, Inertial and Primary Frequency Support from Wind Farms, Wind Farms in Secondary Frequency Control (AGC),	08	L1,L2,L3.

	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 TEXT 1 and TEXT 2. Reference Book 1		

Note 1: Unit 1 to 5 will have internal choice

Note2: Student has to submit one assignment per unit and is evaluated for 10 marks and group activity for 5 marks and Seminar for 5 Marks Group Activity for 5 Marks has to be evaluated through PPT Presentation/ Subject Quiz/Project and 5 marks for subject seminar

Note:3 Out of 5 Units, Unit 4 is a Webinar unit conducted through Google Classroom/Zoom/Cisco WebExetc. and will be delivered by subject faculty

Course Outcomes:

CO1	Explain the fundamentals of MTDC grids, their network architectures, components and control modes
CO2	Differentiate ideal and practical voltage sourced converters
CO3	Simulate AC- MTDC grids for the analysis.
CO4	Explain the concept of power sharing in MTDC grid, load flow solution and post contingency operation.
CO5	Explain protection issues of MTDC grids, including the DC circuit breakers and fault blocking VSC systems and protection strategies

Course Outcomes Mapping with Programme Outcomes.

Sl.No	Course Outcome	Level of Blooms Taxonomy	No. of hours of teaching	Programme Outcome										
				1	2	3	4	5	6	7	8	9	10	11
1.	CO1:	2	08		3	1	2				2	2	2	
2.	CO2.	3	08	2	3	1	2				2		2	2
3.	CO3:	3	08	3	3	1	2				2		2	
4.	CO4:	2	07	3	3	2	2				1		1	1
5.	CO5:	2	08	3	3	1	2				2		2	
Average CO				2	3	1	2				2	1	2	1

Course Outcomes Mapping with Programme Specific Outcomes

Course Outcome	PSO1	PSO2	PSO3
CO1		2	2
CO2		2	2
CO3		3	3
CO4		3	3
CO5	2	2	3
Average CO	**1**	**2**	**3**

Text Books.

1 Nilanjan Ray Chaudhuri et al, "-Terminal Direct-Current Grids Modelling, Analysis, and Control", First Edition, Wiley, 2014

2 Nilanjan Ray Chaudhuri Balarko Chaudhuri Rajat Majumder Amirnaser Yazdani, "Multi-Terminal Direct-Current Grids: Modeling, Analysis, and Control", 1st edition, Wiley India, 2014

Reference Text Books.

1 Epameinondas Kontos , Rodrigo Teixeira Pinto, Pavol Bauer, "Control and Protection of VSC-based Multi-terminal DC Networks", 1st edition, New Age International publisher, 2007

Web Links.

1 https://www.researchgate.net/publication/318299516_Multi-terminal_DC_grids_challenges_and_prospects

2 https://www.sciencedirect.com/science/article/pii/S1110016818302321

Subject Title : POWER QUALITY

Sub.Code:20EPE261	No. of Credits:03=03:0:0 (L - T – P)	No. of Lecture Hours/Week : 03
Exam Duration:03 Hrs	CIE+Asmt+SS+SEE=30+10+05+05+50=100	Total No.of Contact Hours:39

Course Learning Objectives: After the completion of the course the students should be able to

1 Understand the causes of power quality (PQ) and effects of PQ problems, requirement of PQ improvements, and mitigation aspects of PQ problems.
2 Explain the Q definitions, terminologies, standards, benchmarks, monitoring requirements through numerical problems.
3 Explain the passive shunt and series compensation using lossless passive LC components, active shunt compensation using DSTATCOM (distribution static compensators), active series compensation using DVR (dynamic voltage restorer), and combined compensation using UPQC (unified power quality compensator) for mitigation of current-based PQ problems.
4. Understand the methodology to improve the power quality for sensitive loads by various mitigating custom power devices;
5. Analyze the current and voltage related power quality issues;

Unit No	Syllabus Contents	No.of Hours	Blooms Taxnomy level.
1	Power Quality: An Introduction, State of the Art on Power Quality, Classification of Power Quality Problems, Causes of Power Quality Problems, Effects of Power Quality Problems on Users Power Quality Standards and Monitoring: Introduction, State of the Art on Power Quality Standards and Monitoring, Power Quality Terminologies, Power Quality Definitions, Power Quality Standards, Power Quality Monitoring TEXT 1 and TEXT 2. Reference Book1	08	L1,L2,L3.
2	Passive Shunt and Series Compensation: Introduction, State of the Art on Passive Shunt and Series Compensators, Classification of Passive Shunt and Series Compensators, Principle of Operation of Passive Shunt and Series Compensators, Analysis and Design of Passive Shunt Compensators, Modelling, Simulation, and Performance of Passive Shunt and Series Compensators, Numerical Examples. TEXT 1 and TEXT 2	08	L1,L2,L3.
3	Active Shunt Compensation: Introduction, State of the Art on DSTATCOMs, Classification of DSTATCOMs, Principle of Operation of DSTATCOM - Control of DSTATCOMs in UPF Mode of Operation, Design of a Three-Phase Three-Leg VSC-Based DSTATCOM. Numerical Examples. TEXT 1 and TEXT 2.	08	L1,L2,L3.
4	Active Series Compensation: Introduction, State of the Art on Active Series Compensators, Classification of Active Series Compensators, Principle of Operation and Control of Active Series Compensators, Analysis and Design of Active Series Compensators, Numerical Examples.	08	L1,L2,L3.

Unit No	Syllabus Contents	No.of Hours	Blooms Taxnomy level.
	TEXT 1 and TEXT 2.		
5	Unified Power Quality Compensators: Introduction, State of the Art on Unified Power Quality Compensators, Classification of Unified Power Quality Compensators, Principle of Operation and Control of Unified Power Quality Compensators, Numerical Examples. TEXT 1 and TEXT 2.	07	L1,L2,L3.

Note 1: Unit 1 to 5 will have internal choice

Note2: Student has to submit one assignment per unit and is evaluated for 10 marks and group activity for 5 marks and Seminar for 5 Marks

Note:3 Out of 5 Units, Unit2is a Webinar Unit delivered through Google meet/Cisco Webex/Zoom and it will be delivered by Subject Faculty

Course Outcomes:

- CO1 Explain causes, effects of PQ problems and classification of mitigation techniques for PQ problems
- CO2 Explain PQ standards, terminology and monitoring requirements through numerical problems.
- CO3 Explain passive shunt and series compensation using lossless passive components.
- CO4 Explain the design, operation and modeling of active shunt and series compensation equipment.
- CO5 Decide the compensators and filters to keep the power quality indices within the standards..

Course Outcomes Mapping with Programme Outcomes.

Sl.No	Course Outcome	Level of Blooms Taxonomy	No. of hours of teaching	Programme Outcome										
				1	2	3	4	5	6	7	8	9	10	11
1.	**CO1:**	2	8		3	1	2				2		2	2
2.	**CO2.**	2	8	3	3	1	2				2		2	2
3.	**CO3:**	2	8	3	3	1	2				2		2	2
4.	**CO4:**	4	8	3	3	1	2				2		2	2
5.	**CO5:**	5	7	3	3	1	2				2		2	2
Average Program Outcome				3	3	1	2				2		2	2

Course Outcomes Mapping with Programme Specific Outcomes.

Course Outcome	PSO1	PSO2	PSO3
CO1	3		
CO2		2	
CO3			
CO4			1
CO5	3	2	
Average CO	**3**	**2**	**1**

Text Books.

1 Bhim Singh, Ambrish Chandra, Kamal Al-Haddad, "Power Quality Problems and Mitigation", First Edition, John Wiley Sons PVT Ltd, 2015

2 Alexander Kusko and Marc T Thomson, "Power Quality in Electrical Systems", First edition, McGraw Hill 2007

Reference Text Books.

1 Roger C Dugan, Mark F Mc Granaghan,SuryaSantose and H.Wayne Beaty "Electrical Power System Qulaity",2nd edition, Mc Graw Hill publisher, 2017

Web Links.

1 Learning resource by nptel, http://nptel.ac.in/courses/108106025/ Power quality in power distribution systems, Dr. Mahesh Kumar, IIT Madras

Subject Title : UNINTERRUPTIBLE POWER SUPPLY

Sub.Code:20EPE262 | No. of Credits:03=03:0:0 (L - T – P) | No. of Lecture Hours/Week : 03

Exam Duration:03 Hrs | CIE+Asmt+SS+GA+SEE=30+10+5+5+50=100 | Total No.of Contact Hours:39

Course Learning Objectives:

1. To describe sources of harmonics, effects of harmonics in UPS, and their mitigation using active filters..
2. To describe different topologies of active filters, their applications, configurations, control methods, modelling and analysis, and stability issues.
3. To explain the analysis, control, and steady-state operation of unified power quality conditioners
4. To give the concept of reduced parts converters, their operation, modelling, simulation and analysis.
5. To explain reduced part active filters and power quality conditioners, modelling, analysis and design of digital control

Unit No	Syllabus Contents	No.of Hours	Blooms Taxnomy level.
1	Uninterruptible Power Supplies: Classification, Batteries for UPS Applications, Flywheels for UPS Applications, Comparative Analysis of Flywheels and Electrochemical Batteries, Applications of UPS Systems, Parallel Operation, Performance Evaluation of UPS Systems, Power Factor Correction in UPS Systems, Control of UPS Systems, Converters for UPS Systems, Battery Charger/Discharger. TEXT 1 and TEXT 2. Reference Book 1	08	L1,L2,L3.
2	Active Filters: Harmonic Definition, Harmonic Sources in Electrical Systems, Effects of Harmonics, Harmonic Mitigation Methods, Classification of Active Filters, Active Filters for DC/DC Converters, Modelling and Analysis, Control Strategies, Stability Assessment TEXT 1 and TEXT 2. Reference Book 1	08	L1,L2,L3.
3	Unified Power Quality Conditioners: Series–Parallel Configuration, Current Control, Voltage Control, Power Flow and Characteristic Power. Reduced-Parts Uninterruptible Power Supplies: Concept of Reduced-Parts Converters Applied to Single-Phase On-Line UPS Systems, New On-Line UPS Systems Based on Half-Bridge Converters. TEXT 1 and TEXT 2. Reference Book 1	08	L1,L2,L3.
4	New On-Line UPS Systems Based on a Novel AC/DC Rectifier: New Three-Phase On-Line UPS System with Reduced Number of Switches, New Single-Phase to Three-Phase Hybrid Line-Interactive/On-Line UPS System. TEXT 1 and TEXT 2. Reference Book 1	07	L1,L2,L3.

5	Reduced-Parts Active Filters: Reduced-Parts Single-Phase and Three-Phase Active Filters, Reduced-Parts Single-Phase Unified Power Quality Conditioners, Reduced-Parts Single-Phase Series–Parallel Configurations, Reduced-Parts Three-Phase Series–Parallel Configurations. Modelling, Analysis, and Digital Control: Systems Modelling Using the Generalized State Space Averaging Method, Digital Control. TEXT 1 and TEXT 2. Reference Book 1	08	L1,L2,L3.

Note 1: Unit 1 to 5 will have internal choice

Note2: Student has to submit one assignment per unit and is evaluated for 10 marks and group activity for 5 marks and Seminar for 5 Marks Group Activity for 5 Marks has to be evaluated through PPT Presentation/ Subject Quiz/Project and 5 marks for subject seminar

Note:3 Out of 5 Units, Unit 4 is a Webinar unit conducted through Google Classroom/Zoom/Cisco WebExetc. and will be delivered by subject faculty

Course Outcomes:

CO1	Explain classification of UPS, batteries for UPS, parallel operation and performance evaluation and control of UPS systems
CO2	Describe sources of harmonics and their mitigation using active filters
CO3	Describe topologies of active filters, their applications, control methods, modeling analysis, and stability issues.
CO4	Explain steady-state operation and control of unified power quality conditioners
CO5	Explain the concept of reduced parts active filters, their modeling and control.

Course Outcomes Mapping with Programme Outcomes.

Sl.No	Course Outcome	Level of Blooms Taxonomy	No. of hours of teaching	Programme Outcome										
				1	2	3	4	5	6	7	8	9	10	11
1.	CO1:	2	08	2	2	1	2				2		2	
2.	CO2.	3	08	3	3	1	2				2		2	2
3.	CO3:	3	08	3	3	1	2				2		2	
4.	CO4:	2	07	3	3	1	2				3		2	2
5.	CO5:	2	08	3	3	1	2				2		2	

Course Outcomes Mapping with Programme Specific Outcomes

Course Outcome	**PSO1**	**PSO2**	**PSO3**
CO1		2	2

CO2		2	2
CO3		3	3
CO4		3	3
CO5	2	2	3
Average CO	**1**	**2**	**3**

Text Books.

1 Ali Emadi et al, "Uninterruptible Power Supplies and Active Filters", First Edition, CRC Press, 2005

2 Alexander C King, William Knight, "Uninterruptible Power Supplies and Standby Power Systems", 2 nd edition, McGraw-Hill, 2003

Reference Text Books.

1 John Platts, John St. Aubyn, "Uninterruptible Power Supplies", 2 nd edition, IET, 1992

Web Links.

1 https://books.google.co.in/books/about/UPS_System_Design_Handbook.html?id=tqNjAAAACAAJ&redir_esc=y

2 https://www.kohler-ups.ie/ups/product/ups-handbook/

Subject Title : DSP APPLICATIONS TO DRIVES

Sub.Code: 20EPE263	No. of Credits:03=03:0:0 (L - T – P)	No. of Lecture Hours/Week : 03
Exam Duration:03 Hrs	CIE+Asmt+SS+GA+SEE=30+10+5+5+50=100	Total No.of Contact Hours:39

Course Learning Objectives:

1	DSP controller, CPU architecture and instruction set
2	DSP-Based Applications
3	DSP-based control of permanent magnet brushless DC machines.
4	DSP-based vector control of permanent magnet synchronous motors.
5	DSP-based vector control of Induction motors.

Unit No	Syllabus Contents	No.of Hours	Blooms Taxnomy level.
1	Introduction: To the TMS320LF2407 DSP Controller, DSP CPU architecture and instruction set. General Purpose Input/output (GPIO) functionality interrupts on the TMS320LF2407. Programming using Mat Lab. TEXT 1 and TEXT 2. Reference Book 1	08	L1,L2,L3.
2	Analog-to-Digital Converter (ADC), event managers (EVA, EVB). DSP-Based Applications: Of DC-DC buck-boost converters, DSP based control of stepper motors. TEXT 1 and TEXT 2. Reference Book 2	08	L1,L2,L3.
3	DSP-Based control of permanent magnet brushless DC machines, Park and Clarke transformations. TEXT 1 and TEXT 2. Reference Book 1	08	L1,L2,L3.
4	Space Vector Pulse Width Modulation, DSP-based control of permanent magnet synchronous machines. TEXT 1 and TEXT 2. Reference Book 2	08	L1,L2,L3.
5	DSP-based vector control of induction motors TEXT 1 and TEXT 2. Reference Book 2	07	L1,L2,L3.

Note 1: Unit 1 to 5 will have internal choice

Note2: Student has to submit one assignment per unit and is evaluated for 10 marks and group activity for 5 marks and Seminar for 5 Marks

Note:3 Out of 5 Units, Unit 5 is a Webinar unit conducted through Google Classroom/Zoom/Cisco Webex etc and will be delivered by subject faculty

Course Outcomes:

CO1	Explain DSP controller, CPU architecture and to write instruction set for specific task.
CO2	Implement DSP for specific Applications.

CO3 Apply the transformation for machine modelling

CO4 Implement DSP-based vector control of permanent magnet synchronous machine.

CO5 Implement DSP-based vector control of induction motors.

Course Outcomes Mapping with Programme Outcomes.

Sl.No	Course Outcome	Level of Blooms Taxonomy	No. of hours of teaching	1	2	3	4	5	6	7	8	9	10	11
1.	CO1:.	1,2,3	08	3	3			1			1		1	
2.	CO2.	1,2,3	08	3	3	1	2				1		1	
3.	CO3:	1,2	08	3	3						1		1	
4.	CO4:	3,4	08	3	3	1	2							
5.	CO5:	1,2,3	07	3	3	1	2				1		1	
Average Co's				3	3	1	2	1			1		1	

Course Outcomes Mapping with Programme Specific Outcomes

Course Outcome	PSO1	PSO2	PSO3
CO1	3	2	1
CO2	3	2	1
CO3	3	3	1
CO4	3	3	1
CO5	3	3	1
Average CO	**3**	**3**	**1**

Text 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

Reference Text Books.

1 Hugo Guzman, Mario Bermudez, Cristina Martin,Federic Barrero and Mario Duran, Intechopen.com, , “Application of DSP inPower Conversion Systems—A Practical Approach for Multiphase Drives 2015”.

2 A Nagoor Kani , “Digital Signal Processing, 2 edition,McGraw Hill,2013.

Web Links.

1 https://www.researchgate.net/publication/261235058_DSP_implementation_of_electric_drive_control_system

2 https://www.intechopen.com/books/applications-of-digital-signal-processing-through-practical-approach/application-of-dsp-in-power-conversion-systems-a-practical-approach-for-multiphase-drives

3 https://www.analog.com/en/analog-dialogue/articles/dsp-based-control-for-ac-machines.html

Subject Title : Research Methodology

Sub.Code: 20RM27	No. of Credits:02=02:0:0 (L - T – P)	No. of Lecture Hours/Week : 02
Exam Duration:03 Hrs	CIE+Asmt+SS+GA+SEE=30+10+5+5+50=100	Total No.of Contact Hours:26

Course Learning Objectives:

1. To have a basic understanding of the underlying principles of quantitative and qualitative research.
2. To identify the overall process of designing a research study from its inception to its report .
3. To choose the most appropriate research method to address a particular research question.
4. To gain overview of a range of quantitative and qualitative approaches to data analysis.
5. To learn to write research report.

Unit No	Syllabus Contents	No.of Hours	Blooms Taxnomy level.
1	Overview of Research and its types, Research approaches, Significance of Research, Research Methods versus Methodology. Research Process. Criteria of Good Research. Identifying and Identifying research problem , technique Involved in defining a Problem.	05	L1,L2,L3.
2	Introduction to different research designs. Essential constituents of Literature Review. Basic principles of experimental design, Primary data and Secondary Data, methods of primary data collection, classification of secondary data, designing questionnaires and schedules.	05	L1,L2,L3.
3	Sampling Methods Probability sampling: simple random sampling, systematic sampling, stratified sampling, cluster sampling and multistage sampling. Non probability sampling: convenience sampling, judgment sampling, quota sampling. Sampling	05	L1,L2,L3.
4	Processing and analysis of Data Statistical measures and their significance: Central tendencies, variation, skewness, Kurtosis, time series analysis, correlation and regression, Testing of hypotheses: Parametric (t and Chi Square).	05	L1,L2,L3.
5	Essential of Report writing and Ethical issues: Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Ethical issues related to Research, Plagiarism and self- Plagiarism, Publishing.	06	L1,L2,L3.

Note 1: Unit 1 to 5 will have internal choice

Note2: Student has to submit one assignment per unit and is evaluated for 10 marks and group activity for 5 marks and Seminar for 5 Marks

Note:3 Out of 5 Units, Unit 5 is a Webinar unit conducted through Google Classroom/Zoom/Cisco Webex etc and will be delivered by subject faculty

Course Outcomes:

CO1	Student will be able to describe a range of quantitative and qualitative research designs and identify the advantages and disadvantages associated with these designs.
CO2	: Students will be able to choose appropriate quantitative or qualitative method to collect data
CO3	Students will be able to analyze and test the given data using appropriate methods
CO4	Students will be able to design an appropriate mixed-method research study to answer a research question.
CO5	Students will be able to write the research report

Course Outcomes Mapping with Programme Outcomes.

Sl.No	Course Outcome	Level of Blooms Taxonomy	No. of hours of teaching	1	2	3	4	5	6	7	8	9	10	11
1.	CO1:.	1,2,3	08				3			3	3			
2.	CO2.	1,2,3	08				3			3	3			
3.	CO3:	1,2	08				3			3	3			
4.	CO4:	3,4	08				3			3	3			
5.	CO5:	1,2,3	07				3			3	3			
Average Co's							3			3	3			

Text Books.

1 Kothari C.R., Research Methodology Methods and techniques by, New Age International Publishers, 3rd Edition, 2013.

Reference Text Books.

1 Krishnaswami K N, Sivakumar A I and Mathirajan M, "Management Research Methodology", Pearson Education, 2006

2 Levin R I and Rubin D S, Statistics for Management, 7th Edition, Pearson Education

Subject Title : POWER ELECTRONICS LABORATORY-II

Sub.Code:**20EPEL28** No. of Credits:2=0:0:2(L - T – P) No. of Lecture Hours/Week :03

Exam Duration:3 Hrs CIE +SEE=50+50=100 Total No.of Contact Hours:30

Course Learning Objectives:

1 To conduct experiments on DC drive using various types of Power Electronic converters
2 To compute various performance parameters of DC-DC converters.
3 To design various types of DC-DC converters and to find performance of different parameters.
4 To simulate various DC-DC converters onsimulink to find different parameters.
5 To analyse various parameters of DC-DC converters

Expt.No	Experiments	No.of Hours	Blooms Taxnomy level.
1	Analysis of static and dynamic characteristic of MOSFET and IGBT	3	L2,L3,L4
2	Performance of single phase fully controlled and semi-controlled converter for RL load for continuous current mode.	3	L1,L2,L3.
3	Performance of single phase fully controlled and semi-controlled converter for RL load for discontinuous current mode.	3	L1, L2, L3
4	Study of effect of source inductance on the performance of single phase fully controlled converter.	3	L1, L2, L3
5	Performance analysis of three phase fully controlled and semi-controlled converter for RL load for continuous current mode.	3	L2, L3, L4
6	Performance analysis of three phase fully controlled and semi-controlled converter for RL load for discontinuous current mode.	3	L2, L3, L4
7.	Performance analysis of single phase bridge inverter for RL load and voltage control by single pulse width modulation.	3	L2, L3, L4
8.	Performance analysis of two quadrant chopper.	3	L2, L3, L4
9	Diode clamped multilevel inverter.	3	L1, L2, L3
10	ZVS operation of a synchronous buck converter.	3	L1, L2, L3
11	*Simulation of basic DC- DC converters using SEQUEL APP Demo		

Note 1: Laboratory report should be submitted to the subject faculty every week and evaluation will be done on the same week only.* Experiment is for additional skill not for exam.

Course Outcomes:

CO1 To conduct experiments on DC drive using various types of Power Electronic converters

CO2 To compute various performance parameters of DC-DC converters.

CO3 To design various types of DC-DC converters and to find performance of different parameters.

CO4 To simulate various DC-DC converters on simulink to find different parameters..

CO5 To analyse various parameters of DC-DC converters

Course outcomes Mapping with programme outcomes

Sl.No	Course Outcome	Level of Blooms Taxonomy	No. of hours of teaching	Programme Outcome										
				1	2	3	4	5	6	7	8	9	10	11
1.	CO1	L1,L2	06	3	1	1			1					
2.	CO2	L2,L3	06	1	1	3			1					
3.	CO3	L2,L4	06		1	3	1		1					
4.	CO4	L2,L3	06		1	1		3	1					
5.	CO5	L2,L4	06		3	1			1					
Average CO				2	2	2	1	3	1					

Course Outcomes Mapping with Programme Specific Outcomes

Course Outcome	**PSO1**	**PSO2**	**PSO3**
CO1	2		
CO2	3		
CO3	2	2	
CO4	3	2	
CO5	3		
Average CO	3	2	

References Text Books.

1 Ned Mohan, Tore M. Undeland, William P. Robbins"**Power Electronics Converters, Applications, and Design**", Third Edition, Wiley India Pvt. Ltd, 2011

2 Rashid M.H, "Power Electronics – Circuits Devices and Applications", 3rd Edition, Pearson, 2011.

D K Bose"**Modern Power Electronics & AC Drives**", 1st edition, 2012

Web Links.

1 B. G. Fernandes" A course on Power Electronics" http://nptel.ac.in/courses/108101038/

3 K. Gopakumar "A course on Industrial Drives – Power Electronics" http://nptel.ac.in/courses/108108077

Subject Title : PROJECT WORK PHASE – I

Sub.Code: 20EPEP29 No. of Credits:02**=0:0:02 (L :T: P)** No. of Practical Hours/Week: 06

Course Learning Objectives:The students will be able to

1. Analysing basic components of all power electronic devices
2. Modelling of different power electronic circuits.
3. Communicating effectively
4. Demonstrating the critical thinking to solve societal problems with ethics
5. Demonstrating lifelong learning

Unit No	Course Activities	No.of Hours	Blooms Taxonomy level.
1	Each candidate in consultation with the guide/co-guide if any shall pursue literature survey. Survey should consist recent work published in the journals related to the program of study and complete the preliminary requirements of selected Project work. Each student shall prepare relevant introductory project document, and present before a committee comprising of HOD as Chairman, Guide/co-guide if any, and a senior faculty of the department. The evaluation of CIE marks shall be awarded by a committee. CIE marks awarded for project work phase - I, shall be based on the evaluation of Project Report, Project Presentation skill and Question and Answer session.	26	L1-L12

Course Outcomes: After the Course, the students will be able to

CO1 Analyse basic components of all power electronic devices for project

CO2 Model different power electronic circuits.

CO3 Communicate effectively.

CO4 Demonstrate the critical thinking to solve societal problems with ethics,

CO5 Demonstrate lifelong learning

Sl.No	Course Outcome	Level of Blooms Taxonomy	No. of hours of teaching	Programme Outcome			
				1	2	3	4
1.	CO1:	4		1	1	3	1

2.	CO2.	3		1	1	3	3
3.	CO3:	2		1	3	1	
4.	CO4:	5		3	1	2	2
5.	CO5:	6		3	1	2	2
Average CO				2	1	2	2

Course Outcomes Mapping with Programme Specific Outcomes

Course Outcome	PSO1	PSO2	PSO3
CO1	2	3	2
CO2	2	3	2
CO3	2	3	2
CO4	2	3	2
CO5	2	3	2
Average CO	2	3	2

Subject Title : Self-Study – Massive Open Online Course (MOOC)

Sub.Code: 20EPE31 No. of Credits:03**=0:0:03 (L :T: P)** No. of Practical Hours/Week: 06

Course Learning Objectives:The students will be able to

Unit No	Course Activities	No.of Hours	Blooms Taxonomy level.
1	**Massive Open Online Courses (NPTEL/SWAYAM):** List of Massive Open Online Courses (NPTEL/SWAYAM) shall be decided in the Board of Studies meeting. Students shall register for MOOC during 1^{st} /2^{nd} /3^{rd} semester and shall be completed before the last working day of the 3^{rd} semester. The assignment and examination marks (Credits) earned along with certificate should be submitted to the Dean examination.	26	L1-L5

Subject Title**: INTERNSHIP**

Sub.Code: 20EPEI32	No. of Credits:**08=0:0:08** (L :T: P)	No. of Weeks:08
Exam Duration:**03** Hrs	CIE+SEE:**50+50=100**	Total No.of Contact Hours:80

Course Learning Objectives:

1 Learn managerial skills
2 Apply the knowledge to solve practical problems.
3 Communicate effectively
4 Demonstrate the critical thinking
5 Demonstrate lifelong learning

Unit No	Internship activities	No.of Hours	Blooms Taxonomy level.
1	**Internship:** **1.** All the students have to undergo internship of 8 weeks during the vacation of I and II semesters and /or II and III semesters mandatorily. 2 Each candidate shall submit a report about the internship undergone having certificate issued from the organization concerned at the time of Viva-voce examination. 3 The Head of the Department shall constitute review committee for Internship. There shall be three assessments by the review committee during the semester. The candidate shall make presentation on the progress made by him/her before the committee. 4 The Internship Report prepared according to approved guidelines and duly signed by the Guide and Project Co-ordinator shall be submitted to Head of the Department within the specified date as per the academic schedule of the semester. If the Internship report is not submitted within the specified date, then the candidate is deemed to have failed in the Internship Work and redo it in the subsequent semester. 5 Examination shall be conducted during III semester and the prescribed credit shall be counted for the same semester. 6 If a candidate fails to secure 50% of the continuous assessment marks in the internship work, he / she shall not be permitted to submit the report for that particular	30hrs/week	L2-L5

	semester and shall have to redo it in the subsequent semester and satisfy industry/organization requirements.			

Course Outcomes: After successful completion of the course, the students should be able to

CO1 Learn managerial skills

CO2 Apply the knowledge to solve industrial problems.

CO3 Communicate effectively

CO4 Demonstrate the critical thinking

CO5 Demonstrate lifelong learning

Sl.No	Course Outcome	Level of Blooms Taxonomy	No. of hours of teaching	Programme Outcome			
				1	2	3	4
1.	CO1:	3		2	1		3
2.	CO2.	3		3	1	2	2
3.	CO3:	2		1	3	1	
4.	CO4:	4		3	1	2	1
5.	CO5:	4		3	1	2	1
Average CO				2	1	2	2

Course Outcomes Mapping with Programme Specific Outcomes

Course Outcome	PSO1	PSO2	PSO3
CO1	1	2	2
CO2	1	2	2
CO3	1	2	2
CO4	1	2	2
CO5	1	2	2
Average CO	1	2	2

Subject Title : TECHNICAL SEMINAR

Sub.Code:20EPES33 No. of Credits:2=0:0:2(L - T – P) No. of Lecture Hours/Week :16

Course Learning Objectives:

1. Analysing different technical problems in power electronics (PE) field
2. Applying different solution methodologies to solve problems in the PE field
3. Communicate effectively and efficiently
4. Demonstrate critical thinking.
5. Demonstrate lifelong learning.

Unit No	Seminar activity	No.of Hours	Blooms Taxonomy level.
1	**Technical Seminar**: The seminar should be on topic having practical importance and relevance with Power Electronics. The candidate has to refer peer reviewed journals for literature survey of minimum 10 papers. The same should be decided by the student and concerned guide. The candidate will deliver a talk on the topic for half an hour and an assessment will be made by the committee consisting of HOD, PG coordinator, Guide and senior faculty members of the department. The student should submit the report based on his/her survey and is required to make the presentation for evaluation. Seminar work shall be in the form of a report to be assessment submitted by the student at the end of the semester.	26	L2-L5

Note: **Evaluation of Seminar**:

1. Relevance of the seminar topic:10%
2. Literature survey-10%
3. Presentation-40%
4. Report-30%
5. Publications-10%

Course Outcomes: After successful completion of the course, the students should be able to

CO1 Analyse different technical problems in power electronics (PE) field

CO2 Apply different solution methodologies to solve problems in the PE field

CO3 Communicate effectively and efficiently

CO4 Demonstrate critical thinking.

CO5 Demonstrate lifelong learning

Course Outcomes Mapping with Programme Outcomes

Sl.No	Course Outcome	Level of Blooms Taxonomy	No. of hours of teaching	Programme Outcome			
				1	2	3	4
1.	CO1:	3		2	1		3
2.	CO2.	3		3	1	2	2
3.	CO3:	2		1	3	1	
4.	CO4:	4		3	1	2	1
5.	CO5:	4		3	1	2	1
Average CO				2	1	2	2

Course Outcomes Mapping with Programme Specific Outcomes

Course Outcome	PSO1	PSO2	PSO3
CO1	2	2	2
CO2	2	2	2
CO3	2	2	2
CO4	2	2	2
CO5	2	2	2
Average CO	2	2	2

Subject Title : EVALUATION OF PROJECT WORK PHASE – I

Sub.Code: 20EPEP34 No. of Credits:07=0:0:7 (L - T – P) No. of Lecture Hours/Week : 12

Exam Duration:03 Hrs CIE +SEE=50+50=100 Total No.of Contact Hours:00

Course Learning Objectives:The students will be able to

1. Analysing basic components of all power electronic devices
2. Modelling of different power electronic circuits.
3. Communicating effectively
4. Demonstrating the critical thinking to solve societal problems with ethics
5. Demonstrating lifelong learning

Unit No	Course Activities	No.of Hours	Blooms Taxonomy level.
1	Each candidate in consultation with the guide/co-guide if any shall prepare the report consisting of literature survey, problem statement, objectives methodology results and discussion and conclusion of the project work. Each student shall prepare and present the work carried before examiners during the examination. The evaluation of CIE marks shall be awarded by a committee. CIE marks awarded for project work phase - I, shall be based on the evaluation of Project Report, Project Presentation skill and Question and Answer session.	26	L2-L6

Course Outcomes: After the Course, the students will be able to

CO1 Analyse basic components of all power electronic devices for project
CO2 Model different power electronic circuits.
CO3 Communicate effectively.
CO4 Demonstrate the critical thinking to solve societal problems with ethics,
CO5 Demonstrate lifelong learning

Sl.No	Course Outcome	Level of Blooms Taxonomy	No. of hours of teaching	Programme Outcome			
				1	2	3	4
1.	CO1:	4		1	1	3	1

2.	CO2.	3		1	1	3	3
3.	CO3:	2		1	3	1	
4.	CO4:	5		3	1	2	2
5.	CO5:	6		3	1	2	2
Average CO				2	1	2	2

Course Outcomes Mapping with Programme Specific Outcomes

Course Outcome	PSO1	PSO2	PSO3
CO1	2	3	2
CO2	2	3	2
CO3	2	3	2
CO4	2	3	2
CO5	2	3	2
Average CO	2	3	2

Subject Title : PROJECT WORK PHASE – II MID TERM INTERNAL EVALUATION

Sub.Code: 20EPE41 No. of Credits:02**=0:0:02 (L :T: P)** No. of Practical Hours/Week: 06

Course Learning Objectives:The students will be able to

1. Analysing basic components of all power electronic devices
2. Modelling of different power electronic circuits.
3. Communicating effectively
4. Demonstrating the critical thinking to solve societal problems with ethics
5. Demonstrating lifelong learning

Unit No	Course Activities	No.of Hours	Blooms Taxonomy level.
1	Each candidate in consultation with the guide/co-guide if any shall prepare the report consisting of literature survey, problem statement, objectives methodology results and discussion and conclusion of the project work. Each student shall prepare and present the work carried before a committee comprising of HOD as Chairman, Guide/co-guide if any, and a senior faculty of the department. The evaluation of CIE marks shall be awarded by a committee. CIE marks awarded for project work phase -II, shall be based on the evaluation of Project Report, Project Presentation skill and the contribution of the work and justification.	26	L2-L6

Course Outcomes: After the Course, the students will be able to

CO1 Analyse basic components of all power electronic devices for project

CO2 Model different power electronic circuits.

CO3 Communicate effectively.

CO4 Demonstrate the critical thinking to solve societal problems with ethics,

CO5 Demonstrate lifelong learning

Sl.No	Course Outcome	Level of Blooms Taxonomy	No. of hours of teaching	Programme Outcome			
				1	2	3	4
1.	CO1:	4		1	1	3	1

2.	CO2.	3		1	1	3	3
3.	CO3:	2		1	3	1	
4.	CO4:	5		3	1	2	2
5.	CO5:	6		3	1	2	2
Average CO				2	1	2	2

Course Outcomes Mapping with Programme Specific Outcomes

Course Outcome	PSO1	PSO2	PSO3
CO1	2	3	2
CO2	2	3	2
CO3	2	3	2
CO4	2	3	2
CO5	2	3	2
Average CO	2	3	2

Subject Title : PROJECT WORK PHASE EVALUATION AND VIVA-VOCE

Sub.Code:20EPEP42	No. of Credits18=0:0:18 (L - T – P)	No. of Lecture Hours/Week : 00
Exam Duration:03 Hrs	CIE+SEE=100+100=200	Total No.of Contact Hours:00

Course Learning Objectives:The students will be able to

1 Analysing basic components of all power electronic devices
2 Modelling of different power electronic circuits.
3 Communicating effectively
4 Demonstrating the critical thinking to solve societal problems with ethics
5 Demonstrating lifelong learning

Unit No	Course Activities	No.of Hours	Blooms Taxonomy level.
1	Each candidate in consultation with the guide/co-guide if any shall prepare final report consisting of literature survey, problem statement, objectives methodology results and discussion and conclusion of the project work including references. Each student shall prepare and present the work carried before examiners during the examination. The evaluation of CIE marks shall be awarded by a project evaluation committee. CIE marks awarded for project work phase - I, shall be based on the evaluation of Project Report, Project Presentation skill and justification and contribution of the work. **Thesis submission** 1. Before uploading the dissertation report of the major project, guide shall ensure the plagiarism check is done and obtain the certificate. The percentage of plagiarism must be < 25%. In case, the percentage of plagiarism is > 25% the guide shall reject the report and inform the candidate to make necessary corrections and resubmit the same. 2. The candidate shall submit a soft copy of the major project work in the form of a CD which should contain the entire work in both Word and PDF format. Guides after checking the report for completeness as per the format and content, shall upload the report along with the plagiarism report (<25%). The guide shall also choose and submit a panel of 4 external subject experts for evaluation to Dean examination.	26	L2-L6

	3. The guide and the examiners shall independently evaluate and submit the marks in the prescribed format to the Dean examination. The average of the marks awarded by the two examiners shall be the final evaluation marks for the thesis. 4. If the thesis is rejected by the first external examiner the report shall be sent to a second examiner appointed by the panel. If the second examiner also does not approve the dissertation report, the candidate has to carry out the project work once again and shall submit the dissertation report within 8 weeks, in such cases of rejection the candidate shall redo the entire submission of dissertation in softcopy after plagiarism check. 5. The candidate may also choose another topic of dissertation under a new guide if necessary, in such an event the dissertation report shall be submitted within 4 years from the date of admission to the program. 6. If the dissertation report is approved and evaluated by both the examiners and the candidate secures minimum passing marks in the evaluation the dean examination shall inform both the examiners to conduct the viva-voce exam and to submit the viva-voce marks. 7. The internal examiner as per the direction of the dean examination shall arrive at a convenient date to conduct the viva-voce examination of the candidate in consultation with the external examiner with information to the dean examination. 8. The weightage for the evaluation of the project and the performance at the viva-voce shall be as per the scheme specified in the syllabus book. The marks awarded jointly by the examiners, after the viva-voce examination shall be sent to dean examination immediately through online and in a sealed cover. The date of submission of dissertation report may be extended to a maximum of 4 academic years from the date of admission to the first semester M. Tech program		

Course Outcomes: After the Course, the students will be able to

CO1	Analyse basic components of all power electronic devices for project
CO2	Model different power electronic circuits.
CO3	Communicate effectively.
CO4	Demonstrate the critical thinking to solve societal problems with ethics,

CO5 Demonstrate lifelong learning

Sl.No	Course Outcome	Level of Blooms Taxonomy	No. of hours of teaching	Programme Outcome			
				1	2	3	4
1.	CO1:	4		1	1	3	1
2.	CO2.	3		1	1	3	3
3.	CO3:	2		1	3	1	
4.	CO4:	5		3	1	2	2
5.	CO5:	6		3	1	2	2
Average CO				2	1	2	2

Course Outcomes Mapping with Programme Specific Outcomes

Course Outcome	PSO1	PSO2	PSO3
CO1	2	3	2
CO2	2	3	2
CO3	2	3	2
CO4	2	3	2
CO5	2	3	2
Average CO	2	3	2

Dr. AMBEDKAR INSTITUTE OF TECHNOLOGY,

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Scheme of Teaching and Examination

M.Tech POWER EECRTONICS (EPE)

(Effective from Academic year 2018-19)

SCHEME OF TEACHING AND EXAMINATION - 2018-19

M.Tech. POWER EECRTONICS (EPE)

(Total number of credits prescribed for the programme – 100)

I SEMESTER

Sl. No	Subject Code	Title	Teaching Hours /Week		Examination				Credits
			Theory	Practical/ Field work/ Assignment	Duration in hours	I.A. Marks	Theory/ Practical Marks	Total Marks	
1	EPE11	Applied Mathematics	04	--	03	30	70	100	4
2	EPE12	Power Semiconductor Devices and Components	04	--	03	30	70	100	4
3	EPE13	Solid State Power Controllers	04	--	03	30	70	100	4
4	EPE14	Modelling and Simulation of Power Electronics.	04	--	03	30	70	100	4
5	EPE15X	Elective -1	04	--	03	30	70	100	4
6	EPEL16	Power Electronics Laboratory - 1	-	3	03	30	70	100	2
7	EPES17	Seminar	-	3	-	100	-	100	2
8	EPEM18	Mini Project / Industrial Visit /Field Work	-	-	-	100	-	100	2
TOTAL			**20**	**06**	**18**	**380**	**420**	**800**	**26**

Elective -1

Subject Code under 16EPE15X	Title
EPE151	Embedded Systems
EPE152	Power System Harmonics
EPE153	Advanced Control Systems
EPE154	Electric Vehicle Technology

SCHEME OF TEACHING AND EXAMINATION - 2018-19

M.Tech POWER EECRTONICS (EPE)

(Total number of credits prescribed for the programme - 100)

II SEMESTER

Sl. No	Subject Code	Title	Teaching Hours /Week		Examination				Credits
			Theory	Practical/ Field work/ Assignment	Duration in hours	I.A. Marks	Theory/ Practical Marks	Total Marks	
1	EPE21	AC and DC Drives	04	--	03	30	70	100	4
2	EPE22	Switched Mode Power Conversion	04	--	03	30	70	100	4
3	EPE23	Modelling and Analysis of Electrical Machines	04	--	03	30	70	100	4
4	EPE24	FACTS Controllers	04	--	03	30	70	100	4
5	EPE25X	Elective - 2	04	--	03	30	70	100	4
6	EPEM27	Research methodologies	-	3	-	30	70	100	2
7	EPEL26	Power Electronics Laboratory - 2	-	3	03	30	70	100	2
8	EPEM28	Mini Project / Industrial Visit /Field Work				100		100	2
TOTAL			**20**	**06**	**18**	**310**	**490**	**800**	**26**

Elective - 2

Subject Code under EPE25X	Title
EPE251	Integration of Renewable Energy
EPE252	Power Quality
EPE253	Electromagnetic Compatibility in Power Electronics

SCHEME OF TEACHING AND EXAMINATION - 2018-19

M.Tech POWER EECRTONICS (EPE)

(Total number of credits prescribed for the programme - 100)

III SEMESTER

Sl. No	Subject Code	Title	Teaching Hours /Week		Examination				Credits
			Theory	Practical/ Field work/ Assignment	Duration in hours	I.A. Marks	Theory/ Practical Marks	Total Marks	
1	EPE31	Seminar / Presentation on Internship. (After 8 weeks from the date of commencement)	--	--	--	25	--	25	20
2	EPE32	Report on Internship	--	--	--	50	--	50	
3	EPE33	Viva-Voce of Internship	--	--	--	--	50	50	
4	EPE34	Project phase -1	--	--	--	25	--	25	2
		TOTAL	--	--	--	**100**	**50**	**150**	**22**

SCHEME OF TEACHING AND EXAMINATION - 2018-19

M.Tech POWER EECRTONICS (EPE)

(Total number of credits prescribed for the programme - 100)

IV SEMESTER

Sl. No	Subject Code	Title	Teaching Hours /Week		Examination				Credits
			Theory	Practical/ Field work/ Assignment	Duration in hours	I.A. Marks	Theory/ Practical Marks	Total Marks	
1	EPE41	HVDC power Transmission	04	--	03	30	70	100	4
2	EPE42	Elective - 3	04	--	03	30	70	100	4
3	EPE43	Project phase -2	--	--	--	100	-	100	18
4	EPE44	Project and Viva-Voce	--	--	03	--	100 + 100	200	
		TOTAL	**08**	**--**	**09**	**160**	**340**	**500**	**26**

Elective - 3

Subject Code under EPE42X	Title
EPE421	Power quality enhancement using custom power devices.
EPE422	PWM converters and applications
EPE423	DSP applications to drives

Subject title : APPLIED MATHAMATICS				
Subject Code: EPE11	**No. of Credits : 4:0:0:0**		**No. of lecture hours/week : 4**	
Exam Duration : 3 hours	**CIE : 30**	**SEE : 70**	**Total No. of lecture hours: 52**	

Course objective: In this course, students learn

1. The objectives of this course is to acquaint the students with principles of advanced mathematics through linear algebra, transform methods for differential equations, calculus of variations and linear and non-linear programming, that serve as an essential tool for applications of electrical engineering sciences..

Unit No.	Syllabus content	No. of hours
1	**Numerical Methods:** Solution of algebraic and transcendental equations- iterative methods based on second degree equation – Muller method (no derivation), Chebyshev method. Fixed point iteration method (first order), acceleration of convergence- Δ^2- Aitken's method. System of non-linear equations – Newton-Raphson method. Complex roots by Bairstow's method.	10
2	**Numerical Solution of Partial Differential Equations**: Classification of second order equations, parabolic equations-solution of one dimensional heat equation, explicit method, Crank-Nicolson method. Hyperbolic equations- solution of one dimensional wave equation and two-dimensional Laplace equation by explicit method.	10
3	**Linear Algebra I:** Vector spaces, linear dependent, independence, basis and dimension, elementary properties, examples. **Linear Transformations**: Definition, properties, range and null space, rank and nullity, algebra of linear transformations-invertible, singular and non-singular transformations, representation of transformations by matrices.	10
4	**Linear Algebra-II** Computation of Eigen values and Eigen vectors of real symmetric matrices-Jacobian and Given's method. Orthogonal vectors. **Interpolation:** Hermite interpolation, spline interpolation, numerical solution of differential equations – Numerov method.	12
5	**Basic Graph Theory:** Finite and infinite graphs, degree of vertex, walk, trial, circuits and cycles in a graph. Subgraphs, connected and disconnected graphs, components, Euler and Hamiltonian graphs, characterization of eulerian graphs, graph isomorphism. Digraphs, Application to RLC circuit for node analysis and loop analysis with independent sources.	10
	Course outcome: At the end of the course, students will be able to **CO 1**: Employ numerical techniques in order to achieve more accurate values in the computation of roots of algebraic and non-linear equations. **CO2:** Utilize analytical and numerical schemes to solve partial differential equations applicable to engineering problems. **CO3:** Understand vector spaces, basis, linear transformations and the process of obtaining matrix of linear transformations arising in magnification and rotation of images	

	CO4: Apply standard iterative methods to compute eigen values and solve ordinary differential equations. **CO5:** Employ linear and non-linear programming techniques in simulation of network systems and optimization of electrical circuits.	

TEXT BOOKS:

1. **Linear Algebra and its Applications -** David C.Lay et al, Pearson, 5th Edition,2015
2. **Numerical methods in Engineering and Science (with C, C++ & MATLAB)-** B.S.Grewal, Khanna Publishers, 2014
3. **Graph Theory with Applications to Engineering and Computer Science-** NarsinghDeo, PHI, 2012

REFERENCE BOOKS:

1. **Numerical Methods for Scientific and Engineering Computation -** M. K. Jain et al **,** New Age International **,** 9^{th} Edition, 2014
2. **Higher Engineering Mathematics -** B.S. Grewal, Khanna Publishers, 43^{rd}Edition,2015
3. **Linear Algebra-** K.Hoffmanet al, PHI, 2011

Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 4 and Unit 5.

Subject title : POWER SEMICONDUCTOR DEVICES AND COMPONENTS				
Subject Code: EPE12	**No. of Credits : 4:0:0:0**		**No. of lecture hours/week : 4**	
Exam Duration : 3 hours	**CIE : 30**	**SEE : 70**	**Total No. of lecture hours: 52**	

Course objective: In this course, student learn

1. Working of various power semiconductor devices.
2. Analyzing the switching parameters to decide the suitability of application.
3. Modeling and simulation of devices along with protection system.

Unit No.	Syllabus content	No. of hours
1	**Basic Semiconductor Physics:** Introduction, Conduction Processes in Semiconductors pn Junctions, Charge Control Description of pn-Junction Operation, Avalanche Breakdown. **Power Diodes:** Introduction, Basic Structure and I – V characteristics, Breakdown Voltage Considerations, On –State Losses, Switching Characteristics, Schottky Diodes.	10
2	**Bipolar Junction Transistors:** Introduction, Vertical Power Transistor Structures, I-V Characteristics, Physics of BJT Operation, Switching Characteristics,Breakdown Voltages, Second Breakdown, On-State Losses, Safe Operating areas. **Power MOSFETs :**Introduction, Basic Structure, I-V Characteristics, Physics of Device Operation, Switching Characteristics, Operating Limitations and Safe Operating Areas.	12
3	**Thyristors:** Introduction, Basic Structure, I-V Characteristics, Physics of Device Operation, Switching Characteristics, Methods of Improving di/dt and dv/dt Ratings. **Gate Turn-Off Thyristors:** Introduction, Basic Structure and I-V Characteristics, Physics of Turn-Off Operation, GTO Switching Characteristics, Overcurrent Protection of GTOs. **Insulated Gate Bipolar Transistors:** Introduction, Basic Structure, I-V Characteristics, Physics of Device Operation, Latchup in IGBTs, Switching Characteristics, Device Limits and SOAs.	10
4	**Emerging Devices and Circuits:** Introduction, Power Junction Field Effect Transistors, Field-Controlled Thyristor, JFET-Based Devices versus Other Power Devices, MOS-Controlled Thyristors, Power Integrated Circuits, New Semiconductor Materials for Power Devices. **Snubber Circuits:** Function and Types of Snubber Circuits, Diode Snubbers,	10

	Snubber Circuits for Thyristors, Need for Snubbers with Transistors, Turn-Off Snubber, Overvoltage Snubber, Turn-On Snubber, Snubbers for Bridge Circuit Configurations, GTO Snubber Considerations.	
5	**Component Temperature Control and Heat Sinks:** Control of Semiconductor Device Temperatures, Heat Transfer by Conduction, Heat sinks, Heat Transfer by Radiation and Convection. **Design of Magnetic Components:** Magnetic Materials and Cores, Copper Windings, Thermal Considerations, Analysis of a Specific Inductor Design, Inductor Design Procedures, Analysis of a Specific Transformer Design, Eddy Currents, Transformer Leakage Inductance, Transformer Design Procedure, Comparison of Transformer and Inductor Sizes.	10
	Course outcome: At the end of the course, **s**tudents will be able to **CO 1**: Understand the working of various power semiconductor devices **CO2:** Analyze the switching parameters to decide the suitability of application. **CO3:** Modeling and simulation of devices along with protection system	

TEXT BOOKS:

1. **Power Electronics Converters, Applications, and Design-** Ned Mohan et al, Wiley, 3rd Edition,2014

REFERENCE BOOKS:

1. **Power Electronics -** Daniel W Hart **,** McGraw Hill
2. **Power Semiconductor Devices -** B. Jayant Baliga, Springer, 2008

Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 2 and Unit 3.

Subject title : Solid State Power Controllers			
Subject Code: EPE13	**No. of Credits : 4:0:0:0**		**No. of lecture hours/week : 4**
Exam Duration : 3 hours	**CIE : 30**	**SEE : 70**	**Total No. of lecture hours: 52**

Course objective: In this course, student learn

1. Analyzing various operating modes of different power converters.
2. Designing various AC/ DC power converters.
3. Designing of control circuits for power converters using different methods.

Unit No.	Syllabus content	No. of hours
1	**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	14
2	**Inverters:** Principle of operation, performance parameters, single phase bridge inverters and three phase inverters.	10
3	**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.	10
4	**Multilevel Inverters:** Introduction, types, diode clamped multi-level inverters, features & applications.	08
5	**DC-DC Converters:** Principle of operation, analysis of step-down and step-up converters, , Push – Pull (Symmetric) Converters - Analysis of Idealized Circuit in Continuous Mode, Output Characteristics, Half-Bridge Converter, Bridge Converter, Hamilton Circuit, Ćuk Converters.	10
	Course outcome: At the end of the course, students will be able to **CO 1**: Analyze various operating modes of different power converters. **CO2:** Design various power converters. **CO3:** Design control circuits for power converters using different methods.	

TEXT BOOKS/ REFERENCE BOOKS:

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

Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 1 and Unit 3.

Subject title : MODELING AND SIMULATION FOR POWER ELECTRONICS			
Subject Code: EPE14	**No. of Credits : 4:0:0:0**		**No. of lecture hours/week : 4**
Exam Duration : 3 hours	**CIE : 30**	**SEE : 70**	**Total No. of lecture hours: 52**

Course objective: In this course, student learn

1. types of modeling applicable o power electronics
2. types and need for control system
3. control system design for converters
4. to analyze a system and to make use of the information to improve the performance.

Unit No.	Syllabus content	No. of hours
1	**Computer Simulation of Power Electronic Converters and Systems:** Introduction, Challenges in Computer Simulation, Simulation Process, Mechanics of Simulation, Solution Techniques for Time-Domain Analysis, Widely Used, Circuit-Oriented Simulators, Equation Solvers. **Modeling of Systems:** Input-Output relations, Differential Equations and Linearization, State Space Representation, Transfer Function Representation, Block Diagrams, Lagrange method, Circuit Averaging, Bond Graphs, Space Vector Modeling	12
2	**Control System Essentials:** Control System Basics, Control Principles, State - Space Method, Bode Diagram Method, Root Locus Method, State Space Method	10
3	**Digital Controller Design:** Controller Design Techniques, , PID Controller, , Full State Feedback, Regulator Design by Pole Placement, Estimation Design, Tracker : Controller Design	10
4	**Digital Controller Design (continued):** Controlling Voltage, Controlling Current, Control of Induction motor, Output Feedback, Induction motor Control with Output Feedback. **Optimal and Robust Controller Design:** Least Squares Principle, Quadratic Forms, Minimum Energy Principle, Least Square Solution, Weighted Least Squares, Recursive Least Squares, Optimal Control: Linear Quadratic, Induction motor example, Robust Controller Design.	12
5	**Discrete Computation Essentials:** Numeric Formats, Tracking the Base Point in the Fixed Point System, Normalization And Scaling, Arithmetic Algorithms	08

	Course outcome: At the end of the course, **s**tudents will be able to **CO 1**: understand the system concept and apply functional modeling method to model the activities of a static system **CO2:** understand the behavior of a dynamic system and create an analogous model for a dynamic system **CO3:** simulate the operation of a dynamic system and make improvement according to the simulation results	

TEXT BOOKS/ REFERENCE BOOKS:

1. **Power Electronics Converters, Applications, and Design -** Ned Mohan, Wiley, 3rd Edition,2014
2. **Power Electronics Essentials and Applications -** L.Umanand, Wiley, 1st Edition,2014

Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 1 and Unit 4.

Subject title : EMBEDDED SYSTEMS			
Subject Code: EPE151	**No. of Credits : 4:0:0:0**		**No. of lecture hours/week : 4**
Exam Duration : 3 hours	**CIE : 30**	**SEE : 70**	**Total No. of lecture hours: 52**

Course objective: In this course, student learn

1. the concepts of embedded system.
2. embedded system architecture and memory organization.
3. the interprocess communication, modeling, devices and communication buses.
4. realisation of real time operating system.

Unit No.	Syllabus content	No. of hours
1	**Introduction to Embedded Systems:** Embedded Systems, Processor Embedded into a System, Embedded Hardware Units and Devices in a System, Embedded Software in a System, Examples of Embedded Systems, Embedded Systems – on –chip (Soc) and Use of VLSI Circuit Design Technology, Complex Systems Design and Processors, Design of Process in Embedded System, Formulation of System Design, Design Process and Design Examples, Classification of Embedded Systems, Skill required for an Embedded System Designer.	10
2	**Processor Architecture and Memory Organisation:** 8051 Architecture, Real world Interfacing, Introduction to Advanced Architecture, Processor and Memory Organization, Instruction Level Parallelism, Performance Metrics, Memory – Types, Memory – Maps and Addresses, Processor Selection, Memory Selection.	12
3	**Devices and Communication Buses, Interrupt Services:** IO Types and Examples, Serial Communication Devices, Parallel Device Ports, Sophisticated Interfacing Features in Device Ports, Wireless Devices, Timer and Counting Devices, Watchdog Timer, Real Time Clock, Networked Embedded Systems, Serial Bus Device Protocols – Parallel Communication Network Using ISA,PCI, PCI –X and Advanced Protocols.	10

	Device Drivers and Interrupts Service Mechanisms: Programmed – I/O Busy – wait Approach without Interrupt Service Mechanism, ISR Concept, Interrupt Sources, Interrupt Servicing Mechanism, Direct Memory Access	
4	**Program Modelling concepts:** Program Models, DFG Models, State Machine Programming Models for Event – controlled Program Flow. **Interprocess Communication and Synchronization of Processes, Threads and Tasks:** Multiple Processes in an Application, Multiple Threads in an Application, Tasks, Task Status, Task and Data, Clear – cut Distention Between Functions, ISRS and Tasks by their Characteristics, Concept of Semaphores, Shared Data, Interprocess Communication, Signal Function, Semaphore Functions, Message Queue Functions, Mailbox Functions, Pipe Functions, Socket Functions, RPC Functions.	10
5	**Real - Time Operating Systems:** OS Services, Process Management, Timer Functions, Event Functions, Memory management, Device, File and IO Subsystems Management , Interrupt Routines in RTOS Environment and Handling of Interrupt Source Calls, Real – time Operating Systems, Basic Design Using an RTOS, RTOS Task Scheduling Models, Interrupt Latency and Response of the task as performance Metrics, OS Security Issues.	10
	Course outcomes: At the end of the course the student will be able to: 1. Understand the concept of embedded system. 2. Analyse the embedded system architecture and memory organization. 3. Analyse the real time system ARM processor. 4. Realise real time operating system.	

TEXT BOOKS/ REFERENCE BOOKS

1. **Embedded Systems**: Architecture, Programming and Design, Raj Kamal, McGraw Hill, 2nd Edition,2014

Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 3 and Unit 5.

	Subject title : POWER SYSTEM HORMONICS			
	Subject Code: EPE152	**No. of Credits : 4:0:0:0**		**No. of lecture hours/week : 4**
	Exam Duration : 3 hours	**CIE : 30**	**SEE : 70**	**Total No. of lecture hours: 52**

Course objective: In this course, student learn

1. The cause for harmonics in the electronic devices.
2. Measuring and mitigation techniques of harmonics in the systems.
3. Model ling of the Transmission system.

Unit No.	Syllabus content	No. of hours
1	**Fundamentals of Harmonics:** Introduction, Examples of harmonic waveforms, characteristics of harmonics in power systems, measurement of harmonic distortion, power in passive elements, calculation of passive elements, resonance, capacitor banks and reactive power supply, capacitor banks and power factor correction, bus voltage rise and resonance, harmonics in transformers. **Harmonics in Power system:** Introduction, sources of harmonics, transformers, rotating machines, fluorescent lights, static var compensators, cycloconverters. Single phase controlled rectifiers, three phase converters.	10
2	**Effects of Harmonic Distortion on Power System:** Introduction, thermal losses in a harmonic environment, harmonic effects on power system equipment, capacitor banks, transformers, rotating machines, protection, communication and electronic equipment.	10

	Mitigation of Power system Harmonics: Introduction, harmonic filters, power converters, transformers, rotating machines, capacitor banks, harmonic filter design, active filters.	
3	**Limits of Harmonic Distortion:** Introduction, voltage harmonic distortion limits, current harmonic distortion limits. **Harmonic studies – Modelling of System Components:** Introduction, impedance in the presence of harmonics, skin effect, modelling of the high voltage grid, generator modelling, modelling of shunt capacitor banks, series capacitor banks, load models, induction motor modelling. **Transformer Modelling:** Introduction, modelling of two winding transformers, phase sequence admittance matrices, transmission of voltage and current across two winding transformers, transmission matrices and phase admittance matrix, modelling of three and four winding transformers	12
4	**Modelling of Transmission lines/Cables:** Introduction, skin effect, modelling of power lines, Line's series impedance, mutual coupling between conductors, mutually coupled lines, line's shunt capacitance, surge impedance and velocity of propagation, line's series impedance and shunt capacitance – single phase equivalents, the transmission (ABCD) matrix, the admittance matrix, conversion between the transmission and admittance matrices, the nominal pi model – single phase equivalent, the equivalent pi model – voltage and current the line, line losses, the equivalent pi model – single phase equivalent, variations in the network's short circuit capacity, examples – the nominal and equivalent models.	10
5	**Power System Harmonic Studies:** Introduction, harmonic analysis using a computer program, harmonic analysis using spread sheet, harmonic distortion limits, harmonic filter rating, and practical considerations. Harmonic study of simple system, 300 -22 kV power system and low voltage system	10
	Course outcomes: At the end of the course the student will be able to: 1. Analyse the cause for harmonics in the electronic devices. 2. Measure and mitigate the harmonics in the systems. 3. Model the Transmission system.	

TEXT BOOKS

1. **Power System Harmonics-** George J Wakileh, Springer, Reprint, 2014.
2. **Power System Harmonic Analysis**,- Jos Arrillaga et al, Wiley, Reprint, 2014.

REFERENCE BOOKS

1. **Power System Harmonic**s- J. Arrillaga, N.R. Watson, Wiley, 2nd Edition, 2003.

2. **Harmonics and Power Systems**-Francisco C. DE LA Rosa, CRC Press, 1st Edition, 2006	
Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 3 and Unit 4.	

	Subject title : ADVANCED CONTROL SYSTEMS			
	Subject Code: EPE153	**No. of Credits : 4:0:0:0**		**No. of lecture hours/week : 4**
	Exam Duration : 3 hours	**CIE : 30**	**SEE : 70**	**Total No. of lecture hours: 52**

Course objective: In this course, student learn

1. The nonlinear systems and Digital Control Systems
2. The Optimization of the control parameters using different optimization techniques.
3. The Modeling of Digital Control Systems**.**

Unit No.	**Syllabus content**	**No. of hours**
1	**Digital Control:** Control System Terminology, Need of Digital control, Configurations of the Basic Digital Control Scheme, Principle of Signal Conversion, Basic Discrete – Time Signals, Time Domain Models for Discrete – Time Systems, The z – Transform, Transfer Function Models, Frequency Response, Stability on the z – Plane and Jury Stability Criterion, Sample and Hold Systems, Sampled Spectra	10

	and Aliasing, Reconstruction of Analog Signals, Practical Aspects of the choice of Sampling Rate, Principle of Discretization.	
2	**Models of Digital Control Devices and Systems:** Introduction, z – Domain Description of Sampled Continuous – time Plants, z – Domain Description of Samples with Dead – Time, Implementation of Digital Controllers, Tunable PID Controllers, Digital Temperature and Position Control Systems, Stepping Motors and their Control.	10
3	**State Variable Analysis of Digital Control Systems:** Introduction, State Description of Digital Processors, State Description of Sampled continuous – Time Plants, State Description of Systems with Dead Time, Solution of State Difference Equations, Controllability and Observability, Multivariable Systems. **Pole Placement Design and State Observers:** Introduction,Stability Improvement by State Feedback, Necessary and sufficient Conditions for Arbitrary Pole – Placement, State Regulator Design, Design of State Observers, Compensator Design by the Separation Principle, Servo Design – Introduction of the reference Input by Feedforward Control, State Feedback with Integral Control, Digital Control Systems with State Feedback, Deadbeat control by State Feedback and Deadbeat Observers.	12
4	**Quadratic Optimal Control:** Introduction, The Concept of Lyapunov Stability, Lyapunov Functions for Linear Systems, Parameter Optimization and Optimal Control Problems, Quadratic Performance Index, Control Configurations, Optimal State Regulator, Optimal Digital Control Systems, Constrained State Feedback Control.	10
5	**Nonlinear System Analysis:** Introduction, Common nonlinear System Behaviours, Common nonlinearities in Control Systems, Describing Function Fundamentals, Describing Function of Common nonlinearities, Stability Analysis by the Describing Function Method, Concept of Phase Plane Analysis, Construction of Phase Portraits, System Analysis on the Phase Plane, Simple Variable Structure Systems, Lyapunov Stability Definitions, Lyapunov Stability Theorems, Lyapunov Functions for Nonlinear Systems	10
	Course outcomes: At the end of the course the student will be able to: 1. Analyse the nonlinear systems and Digital Control Systems 2. Optimize the control parameters using different optimization techniques. 3. Model Digital Control Systems.	

TEXT BOOKS

1. Digital Control and State Variable Methods (Conventional and Intelligent Control Systems) M Gopal, McGraw Hill, 3rd Edition,2008.

REFERENCE BOOKS

1. Discrete – Time Control Systems, Katsuhiko Ogata.
2. Digital Control Systems, Benjamin C Kuo, Oxford University Press, 2nd Edition,2007.

Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 3 and Unit 5.

	Subject title : ELECTROMAGNETIC COMPATIBILITY IN POWER ELECTRONICS			
	Subject Code: EPE154	**No. of Credits : 4:0:0:0**		**No. of lecture hours/week : 4**
	Exam Duration : 3 hours	**CIE : 30**	**SEE : 70**	**Total No. of lecture hours: 52**

Course objective: In this course, student will be able to:

1. To understand the concept of electromagnetic compatibility and national and international EMC regulations, including the European Union, FCC, and U.S. Military standards.
2. To understand intrinsic noise sources, such as thermal and shot noise etc.
3. To understand electromagnetic compatibility issues associated with digital circuits.
4. To understand conducted emissions on alternating current (ac) and direct current (dc) power lines, as well as EMC issues associated with switching power supplies and variable-speed motor drives.
5. To understand covers electrostatic discharge protection in the design of electronic products. To focus on the importance of a three-prong approach, which includes mechanical, electrical, and software design.

Unit No.	Syllabus content	No. of hours
1	**Electromagnetic Compatibility :** Introduction ,Noise and Interference , Designing for Electromagnetic Compatibility ,Engineering Documentation and EMC ,United States' EMC Regulations ,FCC Regulations ,FCC Part 15, Subpart B , Emissions , Susceptibility , Medical Equipment ,Telecom , Automotive. Canadian EMC Requirements ,European Union's EMC Requirements , Emission Requirements ,Harmonics and Flicker ,Immunity Requirements ,Directives and Standards, International Harmonization ,Military Standards	10
2	**Intrinsic Noise Sources :**Thermal Noise ,Characteristics of Thermal Noise, Equivalent Noise Bandwidth ,Shot Noise ,Contact Noise ,Popcorn Noise Addition of Noise Voltages ,Measuring Random Noise ,Problems .	08
3	**Digital Circuit Radiation :** Differential-Mode Radiation ,Loop Area ,Loop Current , Radiated Emission Envelope ,Controlling Differential-Mode Radiation Board Layout ,Canceling Loops ,Dithered Clocks ,Common-Mode Radiation,Controlling Common-Mode Radiation ,Common-Mode Voltage ,Cable Filtering and Shielding ,Separate I/O Grounds ,Dealing With Common-Mode Radiation Issues ,Problems .	12
4	**Conducted Emissions :** Power Line Impedance , Line Impedance Stabilization Network ,Switched-Mode Power Supplies , Common-Mode Emissions Differential-Mode Emissions , DC-to-DC Converters, Rectifier Diode Noise Power-Line Filters ,Common-Mode Filtering ,Differential-Mode Filtering Leakage Inductance, Filter Mounting, Power Supplies with Integral Power-Line Filters, High-Frequency Noise , Primary-to-Secondary Common-Mode Coupling Frequency Dithering ,Power Supply Instability ,Magnetic Field Emissions Variable Speed Motor Drives ,Harmonic Suppression ,Inductive Input Filters Active Power Factor Correction , AC Line Reactors, Problems	12
5	**Electrostatic Discharge :** Static Generation , Inductive Charging ,Energy Storage , Human Body Model , Static Discharge ,Decay Time ,ESD Protection in Equipment Design ,Preventing ESD Entry , Metallic Enclosures , Input/output Cable Treatment , Insulated Enclosures , Keyboards and Control Panels , Hardening Sensitive Circuits , ESD Grounding ,No grounded Products , Field-Induced Upset , Inductive Coupling , Capacitive Coupling ,Transient Hardened Software Design , Detecting Errors in Program Flow ,Detecting Errors in Input/output , Detecting Errors in Memory .	10
	Course outcomes: A student completing this course should be able to: 1. Explain the various causes and effects of Electromagnetic interference and design systems for EMC. 2. Distinguish intrinsic noise sources and derive means of eliminating them. 3. Analyse and differentiate digital circuit radiation. 4. Discuss various issues related to conducted emissions and apply to switching power supplies and variable –speed motor drives 5. Illustrate the importance of ESD in the design of electronic products and software.	

TEXT BOOKS/ REFERENCE BOOKS

1. **"Electromagnetic Compatibility Engineering",** Henry W Ott, John Wiley Publications, 2009

Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 3 and Unit 4.

<table>
<tr><td rowspan="3"></td><td colspan="4">Subject title : POWER ELECTRONICS LABORATORY-I</td></tr>
<tr><td>Subject Code: EPEL16</td><td colspan="2">No. of Credits : 2:0:0:0</td><td>No. of lecture hours/week : 3</td></tr>
<tr><td>Exam Duration : 3 hours</td><td>CIE : 30</td><td>SEE : 70</td><td>Total No. of lecture hours: 39</td></tr>
</table>

Course objective: In this course, student learn

1. The application of appropriate techniques to solve power electronics problem using modern tools.
2. The working collaboratively on multidisciplinary environment.
3. The computation of the performance of various converters

Unit No.	**Syllabus content**
1	Analysis of static and dynamic characteristic of MOSFET and IGBT

2	Performance of single phase fully controlled and semi-controlled converter for RL load for continuous current mode.
3	Performance of single phase fully controlled and semi-controlled converter for RL load for discontinuous current mode.
4	Study of effect of source inductance on the performance of single phase fully controlled converter.
5	Performance analysis of three phase fully controlled and semi-controlled converter for RL load for continuous current mode.
6	Performance analysis of three phase fully controlled and semi-controlled converter for RL load for discontinuous current mode.
7	Performance analysis of single phase bridge inverter for RL load and voltage control by single pulse width modulation.
8	Performance analysis of two quadrant chopper.
9	Diode clamped multilevel inverter.
10	ZVS operation of a Synchronous buck converter.
	Course outcomes: At the end of the course the student will be able to: 1. Apply appropriate techniques to solve power electronics problem usage of modern tools. 2. Work collaboratively on multidisciplinary environment.

	Subject title : SEMINAR			
	Subject Code: EPES17	**No. of Credits : 2:0:0:0**		**No. of lecture hours/week :**
	Exam Duration :	**CIE : 30**	**SEE : 70**	**Total No. of lecture hours:**

The objective of the seminar is to inculcate self-learning, face audience confidently, enhance communication skill, involve in group discussion and present and exchange 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.

	Subject title : Mini Project / Industrial Visit /Field Work			
	Subject Code: EPEM17	No. of Credits : 2:0:0:0		No. of lecture hours/week :
	Exam Duration :	CIE	SEE	Total No. of lecture hours:

The objective of the Mini Project / Industrial Visit /Field Work is to inculcate self-learning, to carryout mini Innovative projects/to enhance industrial /practical knowledge/ to carryout field work.

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.

	Subject title : AC AND DC DRIVES		
	Subject Code: EPE21	**No. of Credits : 4:0:0:0**	**No. of lecture hours/week : 4**

	Exam Duration : 3 hours	**CIE : 30**	**SEE : 70**	**Total No. of lecture hours: 52**

Course objective: In this course, students learn

1. Different Quadrant operation of Drives
2. The concept of AC/DC variable speed drives.
3. Different control methods of electrical drives.

Unit No.	Syllabus content	No. of hours
1	**Electric Drives**: Introduction – block diagram-classification of electrical drives-choice of electrical drives-fundamental torque equation- components of load torque-steady state stability.	08
2	**DC Drives**: Single Quadrant Drive: 1-Phase semi and half wave converter drives, Two quadrants 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.	12
3	**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, voltage and current source inverter fed induction motor drives, stator and rotor voltage control methods, slip energy recovery drives.	12
4	**Closed Loop Control of AC Drives**: Basic Principle of Vector Control, Direct & Indirect Vector control of Induction Motor, Stator voltage control, Slip regulation, Speed control of static Kramer's drive, Closed loop control of Synchronous Motors. Stepper Motor	10
5	**Applications of Drives:** Drive Consideration for Textile Mills, Steel Rolling Mills, Cranes and Hoist Drives and Centrifugal Pumps.	10
	Course outcome: At the end of the course, students will be able to **CO 1**: Acquainted with the knowledge of various AC/DC drives. **CO2:** Demonstrate the knowledge of different quadrant operation of AC/DC drives. **CO3:** Develop the closed loop control of Electrical Drives.	

TEXT BOOKS:

1. **Modern Power Electronics & AC Drives** - B K Bose, PHI, 2011.
2. **Electric Motor Drives** - R Krishnan, PHI, 2010
3. **Electric Drives-Concepts and Applications-** Vedam Subrahmanyam, McGraw Hill, 2nd edition, 2011.

REFERENCE BOOKS:

1. **Power Electronics- Circuits, Devices and Applications** - Muhammad H. Rashid, Pearson Prentice Hall 2010.
2. **Thyristor Control of AC Motors-** Murphy JMD, Turnbull F.G., Pergamon Press Oxford. 1998.
3. **High Performance Control of AC Drives-** MehrdadEhsani, YiminGaoAlinEmadi, Wiley, 2012.

Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 2 and Unit 3.

Subject title : SWITCHED MODE POWER CONVERSION

	Subject Code: EPE22	No. of Credits : 4:0:0:0		No. of lecture hours/week : 4
	Exam Duration : 3 hours	CIE : 30	SEE : 70	Total No. of lecture hours: 52

Course objective: In this course, students learn
1. the operating principles of different power converters.
2. the Designing and controlling of different power converters
3. the Simulation in computer for Realization of power converters

Unit No.	Syllabus content	No. of hours
1	**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, 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, principle of operation and analysis of buck boost converter analysis, inductors current ripple and output voltage ripple, design considerations for continuous current mode operation.	12
2	Buck-boost converter for 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). **Derived 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.	10
3	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
4	**Control of DC-DC Converter:** Modeling of DC-DC converters, power supply control, control loop stability, small signal analysis, switch transfer function, filter transfer function, PWM transfer function, Type-2 error amplifier with compensation, design, PSpice simulation of feedback control, Type-3 error amplifier with compensation, design.	10
5	**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. **Design of inductor and transformers for SMPC.**	10
	Course outcome: At the end of the course, students will be able to CO 1: Analyze and distinguish the power converters CO 2: Design and control the different power converters CO 3: Simulate in computer for Realization of power converters.	

TEXT BOOKS:

1. **Power Electronics**- Daniel W Hart Tata McGraw Hil l, 2011.
2. **Power Electronics – Circuits Devices and Applications** -Rashid M.H., 3 rd Edition, Pearson, 2011.

REFERENCE BOOKS:

1. **DC-DC Switching Regulator Analysis** - D M Mitchel M cGraw-Hill Ltd, 1988.
2. **Design of Magnetic Compon ents for Switched Mode Power Converters**- Umanand L and Bhatt S R New Age International, New Delhi, 2001
3. **Power Electronics Converters, Applications, and Design**-Ned Mohan, Tore M. Undeland, William P. Robbins 3 rd Edition, Wiley India Pvt Ltd, 2010.

Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 1 and Unit 2.

	Subject title : MODELING AND ANALYSIS OF ELECTRICAL MACHINES			
	Subject Code: EPE23	**No. of Credits : 4:0:0:0**		**No. of lecture hours/week : 4**
	Exam Duration : 3 hours	**CIE : 30**	**SEE : 70**	**Total No. of lecture hours: 52**

Course objective: In this course, student

1. understand the concept of 2-axis representation of an Electrical machine.
2. will know the concepts of representing transfer function model of a DC machine
3. understand the importance of 3-phase to 2-phase conversion
4. will know the representation of 3-phase induction motor in various reference frames

Unit No.	Syllabus content	No. of hours
1	**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. **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
2	**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. **Dynamic Modelling of Three Phase Induction Machine:** Generalized model in arbitrary frame, electromagnetic torque, deviation 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, dynamic simulation. **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.	12
3	**Transformer Modelling**: 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, auto transformers, transmission line and transformers	10
4	**Modelling 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, analysis of steady state operation.	10
5	**Dynamic Analysis of Synchronous Machines:** Dynamic performance during sudden change in input torque and during a 3-phase fault at the machine terminals, approximate transient torque versus rotor angle characteristics, comparison of actual and approximate transient torque-angle characteristics during a sudden change in input torque; first swing transient stability limit, comparison of actual and approximate transient torque-angle characteristics during a 3-phase fault at the machine terminals, critical clearing time, equal area criterion, computer simulation.	10

	Course outcome: At the end of the course, **s**tudents will be able to CO 1: Develop models for linear and nonlinear magnetic circuits CO 2: Determine the developed torque in an electrical machines using the concepts of filed energy and co-energy and determine the dynamic model of a DC Machine CO 3:Determine the dynamic model of an induction machine based on the dq transformation and determine instantaneous torque developed in an induction machine-which leads to advanced control strategies such as vector control and direct torque control.	

TEXT BOOKS:

1. **Generalized Theory of Electrical Machines -** P.S.Bimbra, 5 thEdition, Khanna Publications, 1995.
2. **Electric Motor Drives -** Modeling, Ana lysis & Control, R. Krishnan PHI Learning Private Ltd, 2009.

REFERENCE BOOKS:

1. **Analysis of Electrical Machinery and Drive Systems -** P.C.Krause, Oleg Wasynczuk, Scott D.Sudhoff,2ndEdition, Wiley(India),2010.
2. **Power System Analysis -** Arthur R Bergen and Vijay Vittal 2 nd Edition, Pearson, 2009.
3. **Power System Stability and Control -** PrabhaKundur TMH, 2010.
4. **Dynamic Simulation of Electric Machin ery using Matlab / Simulink -** Chee-MunOng Prentice Hall, 1998.

Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 2 and Unit 5.

	Subject title : FACTS CONTROLLERS			
	Subject Code: EPE24	**No. of Credits : 4:0:0:0**		**No. of lecture hours/week : 4**
	Exam Duration : 3 hours	**CIE : 30**	**SEE : 70**	**Total No. of lecture hours: 52**

Course objective: In this course, students learn

1. Transmission line network of power system and its control parameters.
2. Concept of compensation.
3. Different configuration of Converters and implementation of compensation.

Unit No.	Syllabus content	No. of hours
1	**Control Mechanism:** Background, Electrical Transmission Networks, Conventional Control Mechanisms, Flexible ac Transmission Systems (FACTS), Emerging Transmission Networks. **Reactive-Power Control in Electrical Power Transmission Systems:** Reactive Power, Uncompensated Transmission Lines, Passive Compensation. **Principles of Conventional Reactive-Power Compensators:** Introduction, Synchronous Condensers, The Saturated Reactor (SR), The Thyristor-Controlled Reactor (TCR), and The Thyristor-Controlled Transformer (TCT).	10
2	**Principles of Conventional Reactive-Power Compensators (continued):** The Fixed Capacitor–Thyristor-Controlled Reactor (FC–TCR), The Mechanically Switched Capacitor–Thyristor-Controlled Reactor (MSC–TCR), The Thyristor-Switched Capacitor (TSC), The Thyristor-Switched Capacitor–Thyristor- Controlled Reactor (TSC–TCR), A Comparison of Different SVCs. **SVC Voltage Control:** Introduction Voltage Control.	10
3	**SVC Voltage Control (continued):** Effect of Network Resonances on the Controller Response, The 2nd Harmonic Interaction between the SVC and ac Network, Application of the SVC to Series-Compensated ac Systems, 3rd Harmonic Distortion, Voltage-Controller Design Studies.	10
4	**4SVC Applications:** Introduction, Increase in Steady-State Power-Transfer Capacity, Enhancement of Transient Stability, Augmentation of Power-System Damping - Principle of the SVC Auxiliary Control, Torque Contributions of SVC Controllers, Effect of the Power System, Effect of the SVC,SVC Mitigation of Sub synchronous Resonance (SSR) - Principle of SVC Control, Configuration and Design of the SVC Controller, Rating of an SVC, Prevention of Voltage Instability- Principles of SVC Control- A Case Study, Configuration and Design of the SVC Controller, Rating of an SVC. **The Thyristor-Controlled Series Capacitor (TCSC):** Series Compensation, The TCSC Controller, Operation of the TCSC, The TSSC, Analysis of the TCSC, Capability Characteristics, Harmonic Performance, Losses, Response of the TCSC, Modelling of the TCSC.	12
5	**TCSC Applications:** Introduction, Open-Loop Control, Closed-Loop Control, Improvement of the System-Stability Limit, Enhancement of System Damping, Sub synchronous Resonance (SSR) Mitigation, Voltage-Collapse Prevention. **VSC based FACTS Controllers:** Introduction, The STATCOM, The SSSC, The UPFC, Comparative Evaluation of Different FACTS Controllers.	10

	Course outcome: At the end of the course, students will be able to CO 1: Transmission line network of power system and its control parameters. CO 2: Concept of compensation. CO 3: Different configuration of Converters and implementation of compensation.	

TEXT BOOKS:

1. **Thyristor – Based Facts Controllers for Electrical Transmission Systems-**Mohan Mathur, R., Rajiv. K. Varma IEEE press and John Wiley & Sons, Inc.
2. **Understanding FA CTS: Concepts and Technology of Flexible AC Transmission Systems**- Narain G Hingorani and L. Gyugyi, Wiley India, 2011.

REFERENCE BOOKS:

1. **Flexible AC Transmissi on System**- Y. H. Song and A. T. Johns Institution of Engineering and Technology, 2009.
2. **FACTS Controllers in Power Transmission and Distribution** - K.R Padiyar New Age International, 2007.

Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 1 and Unit 3.

Subject title : INTEGRATION OF RENEWABLE ENERGY			
Subject Code: EPE251	No. of Credits : 4:0:0:0		No. of lecture hours/week : 4
Exam Duration : 3 hours	CIE : 30	SEE : 70	Total No. of lecture hours: 52

Course objective: In this course, student

1. To provide knowledge about the stand alone and grid connected renewable energy systems.
2. To equip with required skills to derive the criteria for the design of power converters for renewable energy applications.
3. To analyze and comprehend the various operating modes of wind electrical generators and solar energy systems.
4. To design different power converters namely AC to DC, DC to DC and AC to AC converters for renewable energy systems.
5. To develop maximum power point tracking algorithms.

Unit No.	Syllabus content	No. of hours
1	**INTRODUCTION:** Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (Cost-GHG Emission) - Qualitative study of different renewable energy resources ocean, Biomass, Hydrogen energy systems: operating principles and characteristics of: Solar PV, Fuel cells, wind electrical systems-control strategy, operating area.	10
2	**ELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION** Review of reference theory fundamentals-principle of operation and analysis: IG, PMSG, SCIG and DFIG.	10
3	**POWER CONVERTERS** Solar: Block diagram of solar photo voltaic system: line commutated converters (inversion mode) - Boost and buck-boost converters- selection Of inverter, battery sizing, array sizing. Wind: three phase AC voltage controllers- AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, Grid Interactive Inverters-matrix converters.	12
4	**ANALYSIS OF WIND AND PV SYSTEMS** Stand alone operation of fixed and variable speed wind energy conversion systems and solar system-Grid connection Issues -Grid integrated PMSG and SCIG Based WECS-Grid Integrated solar system	10
5	**HYBRID RENEWABLE ENERGY SYSTEMS** Need for Hybrid Systems- Range and type of Hybrid systems- Case studies of Wind-PV Maximum Power Point Tracking (MPPT).	10
	Course outcome: At the end of the course, students will be able to CO 1: Explain the environmental aspects of electric energy conversion and impacts of renewable energy. CO 2: Analyse, electrical machines for renewable energy operation CO 3: Analyse, design and construct switch mode power supply circuits (specifically the buck, boost and buck-boost converters). CO 4: Discuss and design grid connected converter systems for renewables. CO 5: Describe the operational principles of wind energy conversion systems, hybrid systems and Integration of multiple renewable energy sources.	

TEXT BOOKS:

1. **Wind energy system ,** Gray, L. Johnson, Prentice hall inc., 1995.
2. **Power electronics Hand book**, Rashid .M. H.Academic press, 2001.

REFERENCE BOOKS:

1. **Wind Electricaal Systems",** S.N.Bhadra, D. Kastha, & S. Banerjee Oxford University Press, 2009
2. **Non conventional energy sources,** Rai. G.D, Khanna publishers, 1993.
3. **Solar energy utilization ,** Rai. G.D., Khanna publishera, 1993.
4. **Non-conventional Energy sources,** B.H.Khan Tata McGraw-hill Publishing Company,2nd Edition, 2009, New Delhi.

Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 3 and Unit 4.

	Subject title : POWER QUALITY			
	Subject Code: EPE252	**No. of Credits : 4:0:0:0**		**No. of lecture hours/week : 4**
	Exam Duration : 3 hours	**CIE : 30**	**SEE : 70**	**Total No. of lecture hours: 52**

Course objective: To enable students learn

1. Use of power electronic components in power system, power quality problems and affects all connected electrical and electronic equipment.
2. Power quality problems of electrical machines and power systems

Unit No.	Syllabus content	No. of hours
1	**Introduction**, power quality-voltage quality, power quality evaluation procedures term and definitions: general classes of power quality problems, transients, long duration voltage variation, short duration voltage variations, voltage imbalance, waveform distortion, power quality terms. **Voltage sags and interruptions:** sources of sags and interruptions, estimating voltage sag performance, fundamental principles of protection, motor starting sags.	10
2	**Transient over voltages:** sources of transient over voltages, principles of over voltages protection, utility capacitor switching transients, fundamentals of harmonics: harmonic distortion, voltage versus transients, harmonic indexes, harmonic sources from commercial loads, harmonic sources from industrial loads, effects of harmonic distortion, intra-harmonics.	12
3	**Applied harmonics:** harmonic distortion evaluations, principles for controlling harmonics, harmonic studies, devices for controlling harmonic distortion, harmonic filters, standards of harmonics.	10
4	**Power quality benchmark:** introduction, benchmark process, power quality contract, power quality state estimation, including power quality in distribution planning. **Distributed generation and quality**: DG technologies, interface to utility system, power quality issues, interconnection standards.	10
5	**Power quality monitoring:** monitoring considerations, power quality measurement equipments, assessment of power quality measurement data, application of intelligent systems, power quality monitoring standards.	10
	Course outcome: At the end of the course, students will be able to CO 1: Identify the causes and effects of power quality problems such as non-sinusoidal wave shapes, voltage outages, and harmonic losses, origins of single-time events such as voltage dips, voltage reductions, and outages. CO 2: Adopt different techniques to mitigate the power quality problems. CO 3: Have a knowledge of guidelines and standards as well as industry regulations and practices for solving power quality problems in a cost-effective manner. CO 4: Have knowledge of estimating the power quality CO 5: Monitor the power quality using different techniques	

TEXT BOOKS:

1. **Electric Power Quality -** Dugan, Roger C, Santoso, Surya, McGraw-Hill professional publication, 2003
2. **Electric Power Quality** - G.T.Heydt **,** stars in a circle publications, 1991

REFERENCE BOOKS:

1. **Modern Power Electronics-**M.H.Rashid, TATA McGraw Hill, 2001
2. **Understanding power quality problems voltage sags and interruptions** - Math H. J. Bollen, IEEE Press, 2000
3. **Power quality in power systems and electrical machines**- Ewald F Fuchs, Mohammad A.S., Masoum, Elsevier, 2009

Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 1 and Unit 2.

Subject title : ELECTRIC VEHICLE TECHNOLOGY			
Subject Code: EPE253	**No. of Credits : 4:0:0:0**		**No. of lecture hours/week : 4**
Exam Duration : 3 hours	**CIE : 30**	**SEE : 70**	**Total No. of lecture hours: 52**

Course objective: To enable students to know the

1. Advantages of EVs.
2. Various drive trains
3. Characteristics of various types of batteries.
4. Concept of hybrid electric vehicles

Unit No.	**Syllabus content**	**No. of hours**
1	**Introduction to electric vehicles (EVs):**Historical perspective. EV advantages and impacts. EVmarket and promotion: infrastructure needs, legislation and regulation, standardization. **Electric vehicle (EV) design options:** EV con figurations: fixed vs. variable gearing, single- vs. multiple-motor drive, in-wheel drives. EV parameters, driving cycles and performance specifications. Choice of system voltage levels: electrical safety and protection.	10
2	**Vehicle dynamics and motor drives:** Road load: vehicle kinetics; effect of velocity, acceleration and grade. EV drive train and components. EV motor drive systems: DC drives, induction motor drives, permanent-magnet synchronous motor drives, switched reluctance motor drives. Control strategies.	10
3	**Batteries:** Battery parameters. Types and characteristics of EV batteries. Battery testing and maintenance; charging schemes. Battery monitoring techniques. Open-circuit voltage and ampere- hour estimation. Battery load levelling	10
4	**Emerging EV technologies:** Hybrid electric vehicles (HEVs): types, operating modes, torque coordination and control, generator/motor requirements.	10
5	**Fuel cell electric vehicles (FEVs):** Fuel cell characteristics, hydrogen storage systems, reformers. Alternative sources of power: super- and ultra- capacitors, flywheels.	10
	Course outcome: At the end of the course, students will be able to CO 1: Describe the configuration of a typical electric vehicle CO 2: Differentiate among different drive trains. CO 3: Understand the limitations and advantages of various battery chemistries. CO 4: Develop strategies for charging various types of batteries. CO 5: Describe the various drive trains of hybrid electric vehicles.	

TEXT BOOKS:

1. **Modern Electric Vehicle Technology**- C.C. Chan and K.T. Chau,Oxford University Press, London
2. **Electric and Hybrid Vehicles**: Iqbal Husain- New York: CRC Press.

REFERENCE BOOKS:

4. **Modern Electric, Hybrid Electric, and Fuel C ell Vehicles:** Fundamentals, Theory and Design- M. Ehsani, Y. Gao, S .E. Gay and A. Emadi, - New York: CRC Press
5. **Web address**- Batteryuniversity.com

Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 1 and Unit 3.

	Subject title : POWER ELECTRONICS LABORATORY-II			
	Subject Code: EPEL26	**No. of Credits : 2:0:0:0**		**No. of lecture hours/week : 3**
	Exam Duration : 3 hours	**CIE : 30**	**SEE : 70**	**Total No. of lecture hours: 39**

Course objective: In this course, student learn

- To discuss in detail performance analysis of DC drive using various types of Power Electronic converters
- To make student understand various types of commutations techniques used for practical purposes.
- To design various types of DC-DC converters and performance analysis of it in detail.

Unit No.	Syllabus content
1	Study and performance analysis of single phase fully controlled converter fed separately excited DC Motor for continuous current mode.
2	Study and performance analysis of single phase fully controlled converter fed separately excited DC Motor for discontinuous current mode.
3	Study and performance analysis of three phase fully controlled converter fed separately excited DC Motor for continuous current mode.
4	Study and performance analysis of three phase fully controlled converter fed separately excited DC Motor for discontinuous current mode.
5	Performance analysis of a practical chopper fed DC Drives system for class-A and class-C commutation and analysis of wave forms in continuous mode.
6	Simulation study of buck, boost and buck- boost converter (basic topologies) and analysis of wave forms for continuous current mode (CCM).
7	Simulation study of buck, boost and buck-boost converter (basic topologies) and analysis of wave forms for discontinuous current mode (DCM).
8	Simulation study of forward converter and fly back converter and performance analysis of various wave forms.
9	Resonant converter simulation study and analysis.
10	Closed loop operation of a buck and boost converter.

Course outcomes:

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

- Make decision on type of converter to be used for a given dc drive with method of control.
- Design a switching regulator circuit for a given specifications.
- Design a close loop control of buck and boost converter.

	Subject title : HVDC POWER TRANSMISSION			
	Subject Code: 18EPE41	**No. of Credits: 3:0:0:0**		**No. of lecture hours/week : 4**
	Exam Duration : 3 hours	**CIE : 50**	**SEE : 50**	**Total No. of lecture hours: 52**

Course objective: In this course, students learn

- DC power transmission and the basic components of a converter, the methods for compensating the reactive power demanded by the converter and the methods for simulation of HVDC systems.
- The types of filters and the characteristics of the system impedance resulting from AC filter designs and different methods of control of HVDC converter and system.
- The design techniques for the main components of an HVDC system.
- The protection of HVDC system and other converter configurations used for the HVDC transmission and the recent trends for HVDC applications.

Unit No.	Syllabus content	No. of hours
1	**DC Power Transmission Technology:** Introduction, comparison with AC transmission, application of DC transmission, description of DC transmission system, Planning of HVDC transmission, modern trends in DC transmission, operating problems. **HVDC Converters**: Introduction to Line commutated converter, choice of converter configuration for any pulse number, analysis of 6 and 12 pulse Graetz bridge converter without overlap, effect of smoothing reactor. Two and Three level voltage source converters, Pulse Width Modulation. Analysis of converter in two and three, and three and four valve conduction modes, LCC bridge characteristics, Twelve pulse converter, detailed analysis of converters. Analysis of Capacitor Commutated and voltage source converters.	12
2	**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. Control of voltage source converter. **Converter Faults and Protection:** Converter faults, protection against over currents, over voltages in converter station, surge arrestor, protection against over voltages. Protection against faults in voltage source converter.	10
3	**Converter Configurations for HVDC Transmission**: Introduction, Voltage Source Converter (VSC), CCC and CSCC HVDC System, 10.4 Multi-Terminal DC Transmission. **Trends for HVDC Applications:** Wind Farm Technology, Modern Voltage Source Converter (VSC) HVDC Systems, 800 kV HVDC System.	10
4	**Harmonics and Filters:** Introduction, Generation of harmonics, design of AC and DC filters. **Power Flow Analysis in AC/DC Systems**: Introduction, dc system model, solution procedure, inclusion of constraints, case study, on line power flow analysis for security control, power flow analysis under dynamic conditions, power flow with VSC based HVDC system.	10
5	**Stability Analysis and Power Modulation:** Introduction to stability concepts, power modulation, practical considerations in the application of modulation controllers, voltage stability, analysis of voltage stability in asynchronous AC/DC system. **Multi Terminal DC Systems**: Introduction, applications, types, control and protection.	10

Course outcomes:

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

1. Explain the importance of DC power transmission, the basic components of a converter and methods for compensating the reactive power.
2. Explain the methods for simulation of HVDC systems and its control.
3. Design filters for eliminating harmonics.
4. Explain the design techniques for the main components of an HVDC system.
5. Analyse the protection of HVDC system and other converter configurations used for the HVDC transmission.
6. Describe the recent trends for HVDC applications.

REFERENCE BOOKS:

1. Chan-Ki Kim et al " HVDC Transmission: Power Conversion Applications in Power Systems" Wiley, 2009
2. K. R. Padiyar, "HVDC Power Transmission Systems", New Age International, 2012.
3. E.W.Kimbark "Direct Current Transmission", Vol.1, Wiley Inter-Science, London, 2006.
4. Arrilaga, "High Voltage Direct Current Transmission", The Institute of Engineering and Technology, 2ndEdition, 2007.
5. S Kamakshaiah and V Kamaraju, "HVDC Transmission", TMH, 2011.
6. Vijay K Sood, "HVDC and FACTs Controllers;Applications of Static Converters in Power Systems, BSP Books Pvt.Ltd.,First Indian reprint 2013.

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Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 1 and Unit 2.

	Subject title : POWER QUALITY ENHANCEMENT USING CUSTOM POWER DEVICES (ELECTIVE- III)			
	Subject Code: 18EPE421	**No. of Credits : 3:0:0:0**		**No. of lecture hours/week : 4**
	Exam Duration : 3 hours	**CIE : 50**	**SEE : 50**	**Total No. of lecture hours: 52**

Course objective: In this course, students learn

Course objective: In this course, students learn

1Use of power electronic components in power system, power quality problems and affects all connected electrical and electronic equipment.

2. Power quality problems of electrical machines and power systems

Unit No.	Syllabus content	No. of hours
1	**Introduction and Characterization of Electric Power Quality:** Electric Power Quality, Power Electronic applications in Power Transmission Systems, 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, Reduced Duration and Customer impact of Outages, Classical Load Balancing Problem, Harmonic Reduction, Voltage Sag or Dip Reduction.	10
2	**Custom Power Devices:** Introduction, Utility-Customer Interface, Custom Power Devices, Custom Power Park, Status of Application of CP Devices, Closed-Loop Switching Control, Second and higher order Systems. **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.	10
3	**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, General Algorithm for generating reference currents, Generating Reference currents when the Source is Unbalanced.	10
4	**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. **Series Compensation of Power Distribution System**: Rectifier Supported DVR, DC Capacitor Supported DVR, DVR Structure, Voltage Restoration, Series Active Filter.	12
5	**Unified Power Quality Conditioner:** UPQC Configurations, Right-Shunt UPQC Characteristics, Left-Shunt UPQC Characteristics, Structure and Control of Right-Shunt UPQC, Structure and Control of Left-Shunt UPQC.	10

Course outcome: At the end of the course, students will be able to

CO 1: Identify the causes and effects of power quality problems such as non-sinusoidal wave shapes, voltage outages, and harmonic losses, origins of single-time events such as voltage dips, voltage reductions, and outages.

CO 2: Adopt different techniques to mitigate the power quality problems using different FACTS controllers.

CO 3: Have knowledge of estimating the power quality

REFERENCE BOOKS:

1. Arindam Ghosh et.al, Power Quality Enhancement Using Custom Power Devices,Kluwer Academic Publishers,2002.
2. Math H J Bollen, "Understanding Power Quality Probl ems; Voltage Sags and Interruptions", Wiley India, 2011.
3. Roger C Dugan, et.al, "Electrical Power Systems Qua lity", 3 rd Edition, TMH, 2012.
4. G T Heydt, "Electric Power Quality", Stars in Circl e Publications, 1991.
5. Ewald F Fuchs, et.el, "Power Quality in Power Syste m and Electrical Machines", Academic Press, Elsevie r, 2009.
6. C. Shankaran "Power Quality", CRC Press, 2013.

Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 4and Unit 5.

	Subject title : PWM CONVERTERS AND APPLICATIONS(ELECTIVE- III)			
	Subject Code: 18EPE422	**No. of Credits : 3:0:0:0**		**No. of lecture hours/week : 4**
	Exam Duration : 3 hours	**CIE : 50**	**SEE : 50**	**Total No. of lecture hours: 52**

Course objective: In this course, students learn

- AC/DC and DC/AC Power Conversion
- Different PWM Techniques
- Computation of switching Losses.
- Dynamic Modelling of PWM converters
- Different compensation techniques.

Unit No.	Syllabus content	No. of hours
1	**AC/DC and DC/AC Power Conversion:** Overview of applications of voltage source converters.	10
2	**PWM Techniques:** Pulse modulation techniques for I – phase bridges, bus clamping PWM, space vector basedPWM, advanced PWM techniques.	10
3	**Loss Calculations:** Practical devices in converters, calculation of switching and conduction losses, compensation fordead time and DC voltage regulation.	12
4	**Modelling:** Dynamic model of PWM converters; constant V/F induction motor drives; estimation of current ripple andtorque ripple in inverter fed drives.	10
5	**Converters with Compensation:** Line-side converters with power factor compensation, reactive power compensation, harmonic current compensation.	10

Course outcomes:

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

- Explain the applications of AC/DC and DC/AC Power Conversion.
- Analyse different PWM Techniques
- Compute switching and conduction losses.
- Implement dynamic modeling of PWM converters
- Discuss different compensation techniques.

REFERENCE BOOKS:

1. Mohan, Undeland and Robbins, "Power Electronics: Converter, Applications and Design", Wiley India, 201 1.
2. Erickson RW, "Fundamentals of Power Electronics", Chapman Hall, 1997.
3. Joseph Vithyathil, "Power Electronics- Principles a nd Applications", TMH, 2011.

Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 3 and Unit 5.

	Subject title : DSP APPLICATIONS TO DRIVES			
	Subject Code: 18EPE423	**No. of Credits : 3:0:0:0**		**No. of lecture hours/week : 4**
	Exam Duration : 3 hours	**CIE : 50**	**SEE : 50**	**Total No. of lecture hours: 52**

Course objective: In this course, students learn

- DSP controller, CPU architecture and instruction set.
- DSP-Based Applications.
- DSP-based vector control of induction motors.

Unit No.	Syllabus content	No. of hours
1	**Introduction:** To the TMS320LF2407 DSP Controller, C2xx DSP CPU architecture and instruction set. General Purpose Input/output (GPIO) functionality interrupts on the TMS320LF2407.	10
2	Analog-to-Digital Converter (ADC), event managers (EVA, EVB). **DSP-Based Applications:** Of DC-DC buck-boost converters, DSP based control of stepper motors,	12
3	DSP-Based control of permanent magnet brushless DC machines, Park and Clarke's transformations.	10
4	Space Vector Pulse Width Modulation, DSP-based control of permanent magnet synchronous machines.	10
5	**DSP-based vector control of induction motors**.	10

Course outcomes:

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

- Explain DSP controller, CPU architecture and to write instruction set for specific task.
- Implement DSP for specific Applications.
- Implement DSP-based vector control of induction motors.

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”, 2 ndEdition, Wiley India,2010
3. Chee-Mun Ong, “Dynamic Simulation of Electric Machinery using Matlab / Simulink”, Prentice Hall,1998.

Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 2 and Unit4.

Dr. AMBEDKAR INSTITUTE OF TECHNOLOGY,

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Bengaluru -56

Scheme of Teaching and Examination

M.Tech POWER EECRTONICS (EPE)

(Effective from Academic year 2016-17)

SCHEME OF TEACHING AND EXAMINATION - 2016-17

M.Tech. POWER EECRTONICS (EPE)

(Total number of credits prescribed for the programme – 100)

I SEMESTER

Sl. No	Subject Code	Title	Teaching Hours /Week		Examination				Credits
			Theory	Practical/ Field work/ Assignment	Duration in hours	I.A. Marks	Theory/ Practical Marks	Total Marks	
1	EPE11	Applied Mathematics	04	--	03	30	70	100	4
2	EPE12	Power Semiconductor Devices and Components	04	--	03	30	70	100	4
3	EPE13	Solid State Power Controllers	04	--	03	30	70	100	4
4	EPE14	Modelling and Simulation of Power Electronics.	04	--	03	30	70	100	4
5	EPE15X	Elective -1	04	--	03	30	70	100	4
6	EPEL16	Power Electronics Laboratory - 1	-	3	03	30	70	100	2
7	EPE17	Seminar	-	3	-	100	-	100	2
8	EPE18	Mini Project / Industrial Visit /Field Work				100			2
TOTAL			**20**	**06**	**18**	**380**	**420**	**800**	**26**

Elective -1

Subject Code under 16EPE15X	Title
EPE151	Embedded Systems
EPE152	Power System Harmonics
EPE153	Advanced Control Systems
EPE154	Electromagnetic Compatibility in Power Electronics

SCHEME OF TEACHING AND EXAMINATION - 2016-17

M.Tech POWER EECRTONICS (EPE)

(Total number of credits prescribed for the programme - 100)

II SEMESTER

Sl. No	Subject Code	Title	Teaching Hours /Week		Examination				Credits
			Theory	Practical/ Field work/ Assignment	Duration in hours	I.A. Marks	Theory/ Practical Marks	Total Marks	
1	EPE21	AC and DC Drives	04	--	03	30	70	100	4
2	EPE22	Switched Mode Power Conversion	04	--	03	30	70	100	4
3	EPE23	Modelling and Analysis of Electrical Machines	04	--	03	30	70	100	4
4	EPE24	FACTS Controllers	04	--	03	30	70	100	4
5	EPE25X	Elective - 2	04	--	03	30	70	100	4
6	EPE27	Research methodologies	-	3	-	30	70	100	2
7	EPEL26	Power Electronics Laboratory - 2	-	3	03	30	70	100	2
8	EPE28	Mini Project / Industrial Visit /Field Work				100			2
TOTAL			**20**	**06**	**18**	**310**	**490**	**800**	**26**

Elective - 2

Subject Code under EPE25X	Title
EPE251	Integration of Renewable Energy
EPE252	Power Quality
EPE253	Electric Vehicle Technology

SCHEME OF TEACHING AND EXAMINATION - 2016-17

M.Tech POWER EECRTONICS (EPE)

(Total number of credits prescribed for the programme - 100)

III SEMESTER

Sl. No	Subject Code	Title	Teaching Hours /Week		Examination				Credits
			Theory	Practical/ Field work/ Assignment	Duration in hours	I.A. Marks	Theory/ Practical Marks	Total Marks	
1	EPE31	Seminar / Presentation on Internship. (After 8 weeks from the date of commencement)	--	--	--	25	--	25	20
2	EPE32	Report on Internship	--	--	--	50	--	50	
3	EPE33	Evaluation and Viva-Voce of Internship	--	--	--	--	50	50	
4	EPE34	Evaluation of Project phase -1	--	--	--	25	--	25	2
		TOTAL	--	--	--	**100**	**50**	**150**	**22**

SCHEME OF TEACHING AND EXAMINATION - 2016-17

M.Tech POWER EECRTONICS (EPE)

(Total number of credits prescribed for the programme - 100)

IV SEMESTER

Sl. No	Subject Code	Title	Teaching Hours /Week		Examination				Credits
			Theory	Practical/ Field work/ Assignment	Duration in hours	I.A. Marks	Theory/ Practical Marks	Total Marks	
1	EPE41	HVDC power Transmission	04	--	03	30	70	100	4
2	EPE42	Elective - 3	04	--	03	30	70	100	4
3	EPE43	Evaluation of Project phase -2	--	--	--	100	-	100	18
4	EPE44	Evaluation of Project and Viva-Voce	--	--	03	--	100 + 100	200	
		TOTAL	**08**	**--**	**09**	**160**	**340**	**500**	**26**

Elective - 3

Subject Code under EPE42X	Title
EPE421	MPPT in solar systems
EPE422	PWM converters and applications
EPE423	DSP applications to drives

Subject title : APPLIED MATHAMATICS				
Subject Code: EPE11	No. of Credits : 4:0:0:0		No. of lecture hours/week : 4	
Exam Duration : 3 hours	CIE : 30	SEE : 70	Total No. of lecture hours: 52	

Course objective: In this course, students learn

1. The objectives of this course is to acquaint the students with principles of advanced mathematics through linear algebra, transform methods for differential equations, calculus of variations and linear and non-linear programming, that serve as an essential tool for applications of electrical engineering sciences..

Unit No.	Syllabus content	No. of hours
1	**Numerical Methods:** Solution of algebraic and transcendental equations- iterative methods based on second degree equation – Muller method (no derivation), Chebyshev method. Fixed point iteration method (first order), acceleration of convergence- Δ^2-Aitken's method. System of non-linear equations – Newton-Raphson method. Complex roots by Bairstow's method.	10
2	**Numerical Solution of Partial Differential Equations**: Classification of second order equations, parabolic equations-solution of one dimensional heat equation, explicit method, Crank-Nicolson method. Hyperbolic equations- solution of one dimensional wave equation and two-dimensional Laplace equation by explicit method.	10
3	**Linear Algebra I:** Vector spaces, linear dependent, independence, basis and dimension, elementary properties, examples. **Linear Transformations**: Definition, properties, range and null space, rank and nullity, algebra of linear transformations-invertible, singular and non-singular transformations, representation of transformations by matrices.	10
4	**Linear Algebra-II** Computation of Eigen values and Eigen vectors of real symmetric matrices-Jacobian and Given's method. Orthogonal vectors. **Interpolation:** Hermite interpolation, spline interpolation, numerical solution of differential equations – Numerov method.	12
5	**Basic Graph Theory:** Finite and infinite graphs, degree of vertex, walk, trial, circuits and cycles in a graph. Subgraphs, connected and disconnected graphs, components, Euler and Hamiltonian graphs, characterization of eulerian graphs, graph isomorphism. Digraphs, Application to RLC circuit for node analysis and loop analysis with independent sources.	10
	Course outcome: At the end of the course, **s**tudents will be able to **CO 1**: Employ numerical techniques in order to achieve more accurate values in the computation of roots of algebraic and non-linear equations. **CO2:** Utilize analytical and numerical schemes to solve partial differential equations applicable to engineering problems. **CO3:** Understand vector spaces, basis, linear transformations and the process of obtaining matrix of linear transformations arising in magnification and rotation of images	

	CO4: Apply standard iterative methods to compute eigen values and solve ordinary differential equations. **CO5:** Employ linear and non-linear programming techniques in simulation of network systems and optimization of electrical circuits.	

TEXT BOOKS:

1. **Linear Algebra and its Applications -** David C.Lay et al, Pearson, 5th Edition,2015
2. **Numerical methods in Engineering and Science (with C, C++ & MATLAB)-** B.S.Grewal, Khanna Publishers, 2014
3. **Graph Theory with Applications to Engineering and Computer Science-** NarsinghDeo, PHI, 2012

REFERENCE BOOKS:

1. **Numerical Methods for Scientific and Engineering Computation -** M. K. Jain et al **,** New Age International **,** 9th Edition, 2014
2. **Higher Engineering Mathematics -** B.S. Grewal, Khanna Publishers, 43rd Edition,2015
3. **Linear Algebra-** K.Hoffmanet al, PHI, 2011

Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 4 and Unit 5.

	Subject title : POWER SEMICONDUCTOR DEVICES AND COMPONENTS			
	Subject Code: EPE12	**No. of Credits : 4:0:0:0**		**No. of lecture hours/week : 4**
	Exam Duration : 3 hours	**CIE : 30**	**SEE : 70**	**Total No. of lecture hours: 52**

Course objective: In this course, student learn

1. Working of various power semiconductor devices.
2. Analyzing the switching parameters to decide the suitability of application.
3. Modeling and simulation of devices along with protection system.

Unit No.	Syllabus content	No. of hours
1	**Basic Semiconductor Physics:** Introduction, Conduction Processes in Semiconductors pn Junctions, Charge Control Description of pn-Junction Operation, Avalanche Breakdown. **Power Diodes:** Introduction, Basic Structure and I – V characteristics, Breakdown Voltage Considerations, On –State Losses, Switching Characteristics, Schottky Diodes.	10
2	**Bipolar Junction Transistors:** Introduction, Vertical Power Transistor Structures, I-V Characteristics, Physics of BJT Operation, Switching Characteristics,Breakdown Voltages, Second Breakdown, On-State Losses, Safe Operating areas. **Power MOSFETs :**Introduction, Basic Structure, I-V Characteristics, Physics of Device Operation, Switching Characteristics, Operating Limitations and Safe Operating Areas.	12
3	**Thyristors:** Introduction, Basic Structure, I-V Characteristics, Physics of Device Operation, Switching Characteristics, Methods of Improving di/dt and dv/dt Ratings. **Gate Turn-Off Thyristors:** Introduction, Basic Structure and I-V Characteristics, Physics of Turn-Off Operation, GTO Switching Characteristics, Overcurrent Protection of GTOs. **Insulated Gate Bipolar Transistors:** Introduction, Basic Structure, I-V Characteristics, Physics of Device Operation, Latchup in IGBTs, Switching Characteristics, Device Limits and SOAs.	10
4	**Emerging Devices and Circuits:** Introduction, Power Junction Field Effect Transistors, Field-Controlled Thyristor, JFET-Based Devices versus Other Power Devices, MOS-Controlled Thyristors, Power Integrated Circuits, New Semiconductor Materials for Power Devices. **Snubber Circuits:** Function and Types of Snubber Circuits, Diode Snubbers,	10

	Snubber Circuits for Thyristors, Need for Snubbers with Transistors, Turn-Off Snubber, Overvoltage Snubber, Turn-On Snubber, Snubbers for Bridge Circuit Configurations, GTO Snubber Considerations.	
5	**Component Temperature Control and Heat Sinks:** Control of Semiconductor Device Temperatures, Heat Transfer by Conduction, Heat sinks, Heat Transfer by Radiation and Convection. **Design of Magnetic Components:** Magnetic Materials and Cores, Copper Windings, Thermal Considerations, Analysis of a Specific Inductor Design, Inductor Design Procedures, Analysis of a Specific Transformer Design, Eddy Currents, Transformer Leakage Inductance, Transformer Design Procedure, Comparison of Transformer and Inductor Sizes.	10
	Course outcome: At the end of the course, **s**tudents will be able to **CO 1**: Understand the working of various power semiconductor devices **CO2:** Analyze the switching parameters to decide the suitability of application. **CO3:** Modeling and simulation of devices along with protection system	

TEXT BOOKS:

1. **Power Electronics Converters, Applications, and Design-** Ned Mohan et al, Wiley, 3rd Edition,2014

REFERENCE BOOKS:

1. **Power Electronics -** Daniel W Hart **,** McGraw Hill
2. **Power Semiconductor Devices -** B. Jayant Baliga, Springer, 2008

Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 2 and Unit 3.

	Subject title : Solid State Power Controllers			
	Subject Code: EPE13	No. of Credits : 4:0:0:0		No. of lecture hours/week : 4
	Exam Duration : 3 hours	CIE : 30	SEE : 70	Total No. of lecture hours: 52

Course objective: In this course, student learn

1. Analyzing various operating modes of different power converters.
2. Designing various AC/ DC power converters.
3. Designing of control circuits for power converters using different methods.

Unit No.	Syllabus content	No. of hours
1	**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	14
2	**Inverters:** Principle of operation, performance parameters, single phase bridge inverters and three phase inverters.	10
3	**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.	10
4	**Multilevel Inverters:** Introduction, types, diode clamped multi-level inverters, features & applications.	08
5	**DC-DC Converters:** Principle of operation, analysis of step-down and step-up converters, , Push – Pull (Symmetric) Converters - Analysis of Idealized Circuit in Continuous Mode, Output Characteristics, Half-Bridge Converter, Bridge Converter, Hamilton Circuit, Ćuk Converters.	10
	Course outcome: At the end of the course, students will be able to **CO 1**: Analyze various operating modes of different power converters. **CO2:** Design various power converters. **CO3:** Design control circuits for power converters using different methods.	

TEXT BOOKS/ REFERENCE BOOKS:

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

Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 1 and Unit 3.

	Subject title : MODELING AND SIMULATION FOR POWER ELECTRONICS			
	Subject Code: EPE14	**No. of Credits : 4:0:0:0**		**No. of lecture hours/week : 4**
	Exam Duration : 3 hours	**CIE : 30**	**SEE : 70**	**Total No. of lecture hours: 52**

Course objective: In this course, student learn

1. types of modeling applicable o power electronics
2. types and need for control system
3. control system design for converters
4. to analyze a system and to make use of the information to improve the performance.

Unit No.	Syllabus content	No. of hours
1	**Computer Simulation of Power Electronic Converters and Systems:** Introduction, Challenges in Computer Simulation, Simulation Process, Mechanics of Simulation, Solution Techniques for Time-Domain Analysis, Widely Used, Circuit-Oriented Simulators, Equation Solvers. **Modeling of Systems:** Input-Output relations, Differential Equations and Linearization, State Space Representation, Transfer Function Representation, Block Diagrams, Lagrange method, Circuit Averaging, Bond Graphs, Space Vector Modeling	12
2	**Control System Essentials:** Control System Basics, Control Principles, State - Space Method, Bode Diagram Method, Root Locus Method, State Space Method	10
3	**Digital Controller Design:** Controller Design Techniques, , PID Controller, , Full State Feedback, Regulator Design by Pole Placement, Estimation Design, Tracker : Controller Design	10
4	**Digital Controller Design (continued):** Controlling Voltage, Controlling Current, Control of Induction motor, Output Feedback, Induction motor Control with Output Feedback. **Optimal and Robust Controller Design:** Least Squares Principle, Quadratic Forms, Minimum Energy Principle, Least Square Solution, Weighted Least Squares, Recursive Least Squares, Optimal Control: Linear Quadratic, Induction motor example, Robust Controller Design.	12
5	**Discrete Computation Essentials:** Numeric Formats, Tracking the Base Point in the Fixed Point System, Normalization And Scaling, Arithmetic Algorithms	08

	Course outcome: At the end of the course, **s**tudents will be able to **CO 1**: understand the system concept and apply functional modeling method to model the activities of a static system **CO2:** understand the behavior of a dynamic system and create an analogous model for a dynamic system **CO3:** simulate the operation of a dynamic system and make improvement according to the simulation results	

TEXT BOOKS/ REFERENCE BOOKS:

1. **Power Electronics Converters, Applications, and Design -** Ned Mohan, Wiley, 3rd Edition,2014
2. **Power Electronics Essentials and Applications -** L.Umanand, Wiley, 1st Edition,2014

Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 1 and Unit 4.

	Subject title : EMBEDDED SYSTEMS			
	Subject Code: EPE151	**No. of Credits : 4:0:0:0**		**No. of lecture hours/week : 4**
	Exam Duration : 3 hours	**CIE : 30**	**SEE : 70**	**Total No. of lecture hours: 52**

Course objective: In this course, student learn

1. the concepts of embedded system.
2. embedded system architecture and memory organization.
3. the interprocess communication, modeling, devices and communication buses.
4. realisation of real time operating system.

Unit No.	Syllabus content	No. of hours
1	**Introduction to Embedded Systems:** Embedded Systems, Processor Embedded into a System, Embedded Hardware Units and Devices in a System, Embedded Software in a System, Examples of Embedded Systems, Embedded Systems – on –chip (Soc) and Use of VLSI Circuit Design Technology, Complex Systems Design and Processors, Design of Process in Embedded System, Formulation of System Design, Design Process and Design Examples, Classification of Embedded Systems, Skill required for an Embedded System Designer.	10
2	**Processor Architecture and Memory Organisation:** 8051 Architecture, Real world Interfacing, Introduction to Advanced Architecture, Processor and Memory Organization, Instruction Level Parallelism, Performance Metrics, Memory – Types, Memory – Maps and Addresses, Processor Selection, Memory Selection.	12
3	**Devices and Communication Buses, Interrupt Services:** IO Types and Examples, Serial Communication Devices, Parallel Device Ports, Sophisticated Interfacing Features in Device Ports, Wireless Devices, Timer and Counting Devices, Watchdog Timer, Real Time Clock, Networked Embedded Systems, Serial Bus Device Protocols – Parallel Communication Network Using ISA,PCI, PCI –X and Advanced Protocols.	10

	Device Drivers and Interrupts Service Mechanisms: Programmed – I/O Busy – wait Approach without Interrupt Service Mechanism, ISR Concept, Interrupt Sources, Interrupt Servicing Mechanism, Direct Memory Access	
4	**Program Modelling concepts:** Program Models, DFG Models, State Machine Programming Models for Event – controlled Program Flow. **Interprocess Communication and Synchronization of Processes, Threads and Tasks:** Multiple Processes in an Application, Multiple Threads in an Application, Tasks, Task Status, Task and Data, Clear – cut Distention Between Functions, ISRS and Tasks by their Characteristics, Concept of Semaphores, Shared Data, Interprocess Communication, Signal Function, Semaphore Functions, Message Queue Functions, Mailbox Functions, Pipe Functions, Socket Functions, RPC Functions.	10
5	**Real - Time Operating Systems:** OS Services, Process Management, Timer Functions, Event Functions, Memory management, Device, File and IO Subsystems Management , Interrupt Routines in RTOS Environment and Handling of Interrupt Source Calls, Real – time Operating Systems, Basic Design Using an RTOS, RTOS Task Scheduling Models, Interrupt Latency and Response of the task as performance Metrics, OS Security Issues.	10
	Course outcomes: At the end of the course the student will be able to: 1. Understand the concept of embedded system. 2. Analyse the embedded system architecture and memory organization. 3. Analyse the real time system ARM processor. 4. Realise real time operating system.	

TEXT BOOKS/ REFERENCE BOOKS

1. **Embedded Systems**: Architecture, Programming and Design, Raj Kamal, McGraw Hill, 2nd Edition,2014

Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 3 and Unit 5.

<table>
<tr><td rowspan="3"></td><td colspan="4">Subject title : POWER SYSTEM HORMONICS</td></tr>
<tr><td>Subject Code: EPE152</td><td colspan="2">No. of Credits : 4:0:0:0</td><td>No. of lecture hours/week : 4</td></tr>
<tr><td>Exam Duration : 3 hours</td><td>CIE : 30</td><td>SEE : 70</td><td>Total No. of lecture hours: 52</td></tr>
<tr><td colspan="5">Course objective: In this course, student learn

1. The cause for harmonics in the electronic devices.
2. Measuring and mitigation techniques of harmonics in the systems.
3. Model ling of the Transmission system.</td></tr>
</table>

Unit No.	Syllabus content	No. of hours
1	**Fundamentals of Harmonics:** Introduction, Examples of harmonic waveforms, characteristics of harmonics in power systems, measurement of harmonic distortion, power in passive elements, calculation of passive elements, resonance, capacitor banks and reactive power supply, capacitor banks and power factor correction, bus voltage rise and resonance, harmonics in transformers. **Harmonics in Power system:** Introduction, sources of harmonics, transformers, rotating machines, fluorescent lights, static var compensators, cycloconverters. Single phase controlled rectifiers, three phase converters.	10
2	**Effects of Harmonic Distortion on Power System:** Introduction, thermal losses in a harmonic environment, harmonic effects on power system equipment, capacitor banks, transformers, rotating machines, protection, communication and electronic equipment.	10

	Mitigation of Power system Harmonics: Introduction, harmonic filters, power converters, transformers, rotating machines, capacitor banks, harmonic filter design, active filters.	
3	**Limits of Harmonic Distortion:** Introduction, voltage harmonic distortion limits, current harmonic distortion limits. **Harmonic studies – Modelling of System Components:** Introduction, impedance in the presence of harmonics, skin effect, modelling of the high voltage grid, generator modelling, modelling of shunt capacitor banks, series capacitor banks, load models, induction motor modelling. **Transformer Modelling:** Introduction, modelling of two winding transformers, phase sequence admittance matrices, transmission of voltage and current across two winding transformers, transmission matrices and phase admittance matrix, modelling of three and four winding transformers	12
4	**Modelling of Transmission lines/Cables:** Introduction, skin effect, modelling of power lines, Line's series impedance, mutual coupling between conductors, mutually coupled lines, line's shunt capacitance, surge impedance and velocity of propagation, line's series impedance and shunt capacitance – single phase equivalents, the transmission (ABCD) matrix, the admittance matrix, conversion between the transmission and admittance matrices, the nominal pi model – single phase equivalent, the equivalent pi model – voltage and current the line, line losses, the equivalent pi model – single phase equivalent, variations in the network's short circuit capacity, examples – the nominal and equivalent models.	10
5	**Power System Harmonic Studies:** Introduction, harmonic analysis using a computer program, harmonic analysis using spread sheet, harmonic distortion limits, harmonic filter rating, and practical considerations. Harmonic study of simple system, 300 -22 kV power system and low voltage system	10
	Course outcomes: At the end of the course the student will be able to: 1. Analyse the cause for harmonics in the electronic devices. 2. Measure and mitigate the harmonics in the systems. 3. Model the Transmission system.	

TEXT BOOKS

1. **Power System Harmonics-** George J Wakileh, Springer, Reprint, 2014.
2. **Power System Harmonic Analysis**,- Jos Arrillaga et al, Wiley, Reprint, 2014.

REFERENCE BOOKS

1. **Power System Harmonic**s- J. Arrillaga, N.R. Watson, Wiley, 2nd Edition, 2003.

2. **Harmonics and Power Systems-**Francisco C. DE LA Rosa, CRC Press, 1st Edition, 2006	
Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 3 and Unit 4.	

	Subject title : ADVANCED CONTROL SYSTEMS			
	Subject Code: EPE153	**No. of Credits : 4:0:0:0**		**No. of lecture hours/week : 4**
	Exam Duration : 3 hours	**CIE : 30**	**SEE : 70**	**Total No. of lecture hours: 52**

Course objective: In this course, student learn

1. The nonlinear systems and Digital Control Systems
2. The Optimization of the control parameters using different optimization techniques.
3. The Modeling of Digital Control Systems**.**

Unit No.	**Syllabus content**	**No. of hours**
1	**Digital Control:** Control System Terminology, Need of Digital control, Configurations of the Basic Digital Control Scheme, Principle of Signal Conversion, Basic Discrete – Time Signals, Time Domain Models for Discrete – Time Systems, The z – Transform, Transfer Function Models, Frequency Response, Stability on the z – Plane and Jury Stability Criterion, Sample and Hold Systems, Sampled Spectra	10

	and Aliasing, Reconstruction of Analog Signals, Practical Aspects of the choice of Sampling Rate, Principle of Discretization.	
2	**Models of Digital Control Devices and Systems:** Introduction, z – Domain Description of Sampled Continuous – time Plants, z – Domain Description of Samples with Dead – Time, Implementation of Digital Controllers, Tunable PID Controllers, Digital Temperature and Position Control Systems, Stepping Motors and their Control.	10
3	**State Variable Analysis of Digital Control Systems:** Introduction, State Description of Digital Processors, State Description of Sampled continuous – Time Plants, State Description of Systems with Dead Time, Solution of State Difference Equations, Controllability and Observability, Multivariable Systems. **Pole Placement Design and State Observers:** Introduction,Stability Improvement by State Feedback, Necessary and sufficient Conditions for Arbitrary Pole – Placement, State Regulator Design, Design of State Observers, Compensator Design by the Separation Principle, Servo Design – Introduction of the reference Input by Feedforward Control, State Feedback with Integral Control, Digital Control Systems with State Feedback, Deadbeat control by State Feedback and Deadbeat Observers.	12
4	**Quadratic Optimal Control:** Introduction, The Concept of Lyapunov Stability, Lyapunov Functions for Linear Systems, Parameter Optimization and Optimal Control Problems, Quadratic Performance Index, Control Configurations, Optimal State Regulator, Optimal Digital Control Systems, Constrained State Feedback Control.	10
5	**Nonlinear System Analysis:** Introduction, Common nonlinear System Behaviours, Common nonlinearities in Control Systems, Describing Function Fundamentals, Describing Function of Common nonlinearities, Stability Analysis by the Describing Function Method, Concept of Phase Plane Analysis, Construction of Phase Portraits, System Analysis on the Phase Plane, Simple Variable Structure Systems, Lyapunov Stability Definitions, Lyapunov Stability Theorems, Lyapunov Functions for Nonlinear Systems	10
	Course outcomes: At the end of the course the student will be able to: 1. Analyse the nonlinear systems and Digital Control Systems 2. Optimize the control parameters using different optimization techniques. 3. Model Digital Control Systems.	

TEXT BOOKS

1. Digital Control and State Variable Methods (Conventional and Intelligent Control Systems) M Gopal, McGraw Hill, 3rd Edition,2008.

REFERENCE BOOKS

1. Discrete – Time Control Systems, Katsuhiko Ogata.
2. Digital Control Systems, Benjamin C Kuo, Oxford University Press, 2nd Edition,2007.

Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 3 and Unit 5.

	Subject title : ELECTROMAGNETIC COMPATIBILITY IN POWER ELECTRONICS			
	Subject Code: EPE154	**No. of Credits : 4:0:0:0**		**No. of lecture hours/week : 4**
	Exam Duration : 3 hours	**CIE : 30**	**SEE : 70**	**Total No. of lecture hours: 52**

Course objective: In this course, student will be able to:

1. To understand the concept of electromagnetic compatibility and national and international EMC regulations, including the European Union, FCC, and U.S. Military standards.
2. To understand intrinsic noise sources, such as thermal and shot noise etc.
3. To understand electromagnetic compatibility issues associated with digital circuits.
4. To understand conducted emissions on alternating current (ac) and direct current (dc) power lines, as well as EMC issues associated with switching power supplies and variable-speed motor drives.
5. To understand covers electrostatic discharge protection in the design of electronic products. To focus on the importance of a three-prong approach, which includes mechanical, electrical, and software design.

Unit No.	Syllabus content	No. of hours
1	**Electromagnetic Compatibility :** Introduction ,Noise and Interference , Designing for Electromagnetic Compatibility ,Engineering Documentation and EMC ,United States' EMC Regulations ,FCC Regulations ,FCC Part 15, Subpart B , Emissions , Susceptibility , Medical Equipment ,Telecom , Automotive. Canadian EMC Requirements ,European Union's EMC Requirements , Emission Requirements ,Harmonics and Flicker ,Immunity Requirements ,Directives and Standards, International Harmonization ,Military Standards	10
2	**Intrinsic Noise Sources :**Thermal Noise ,Characteristics of Thermal Noise, Equivalent Noise Bandwidth ,Shot Noise ,Contact Noise ,Popcorn Noise Addition of Noise Voltages ,Measuring Random Noise ,Problems .	08
3	**Digital Circuit Radiation :** Differential-Mode Radiation ,Loop Area ,Loop Current , Radiated Emission Envelope ,Controlling Differential-Mode Radiation Board Layout ,Canceling Loops ,Dithered Clocks ,Common-Mode Radiation,Controlling Common-Mode Radiation ,Common-Mode Voltage ,Cable Filtering and Shielding ,Separate I/O Grounds ,Dealing With Common-Mode Radiation Issues ,Problems .	12
4	**Conducted Emissions :** Power Line Impedance , Line Impedance Stabilization Network ,Switched-Mode Power Supplies , Common-Mode Emissions Differential-Mode Emissions , DC-to-DC Converters, Rectifier Diode Noise Power-Line Filters ,Common-Mode Filtering ,Differential-Mode Filtering Leakage Inductance, Filter Mounting, Power Supplies with Integral Power-Line Filters, High-Frequency Noise , Primary-to-Secondary Common-Mode Coupling Frequency Dithering ,Power Supply Instability ,Magnetic Field Emissions Variable Speed Motor Drives ,Harmonic Suppression ,Inductive Input Filters Active Power Factor Correction , AC Line Reactors, Problems	12
5	**Electrostatic Discharge :** Static Generation , Inductive Charging ,Energy Storage , Human Body Model , Static Discharge ,Decay Time ,ESD Protection in Equipment Design ,Preventing ESD Entry , Metallic Enclosures , Input/output Cable Treatment , Insulated Enclosures , Keyboards and Control Panels , Hardening Sensitive Circuits , ESD Grounding ,No grounded Products , Field-Induced Upset , Inductive Coupling , Capacitive Coupling ,Transient Hardened Software Design , Detecting Errors in Program Flow ,Detecting Errors in Input/output , Detecting Errors in Memory .	10
	Course outcomes: A student completing this course should be able to: 1. Explain the various causes and effects of Electromagnetic interference and design systems for EMC. 2. Distinguish intrinsic noise sources and derive means of eliminating them. 3. Analyse and differentiate digital circuit radiation. 4. Discuss various issues related to conducted emissions and apply to switching power supplies and variable –speed motor drives 5. Illustrate the importance of ESD in the design of electronic products and software.	

TEXT BOOKS/ REFERENCE BOOKS

1. **"Electromagnetic Compatibility Engineering",** Henry W Ott, John Wiley Publications, 2009

Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 3 and Unit 4.

<table>
<tr><td rowspan="3"></td><td colspan="4">Subject title : POWER ELECTRONICS LABORATORY-I</td></tr>
<tr><td>Subject Code: EPEL16</td><td colspan="2">No. of Credits : 2:0:0:0</td><td>No. of lecture hours/week : 3</td></tr>
<tr><td>Exam Duration : 3 hours</td><td>CIE : 30</td><td>SEE : 70</td><td>Total No. of lecture hours: 39</td></tr>
<tr><td colspan="5">Course objective: In this course, student learn
1. The application of appropriate techniques to solve power electronics problem using modern tools.
2. The working collaboratively on multidisciplinary environment.
3. The computation of the performance of various converters</td></tr>
<tr><td>Unit No.</td><td colspan="4">Syllabus content</td></tr>
<tr><td>1</td><td colspan="4">Analysis of static and dynamic characteristic of MOSFET and IGBT</td></tr>
</table>

2	Performance of single phase fully controlled and semi-controlled converter for RL load for continuous current mode.
3	Performance of single phase fully controlled and semi-controlled converter for RL load for discontinuous current mode.
4	Study of effect of source inductance on the performance of single phase fully controlled converter.
5	Performance analysis of three phase fully controlled and semi-controlled converter for RL load for continuous current mode.
6	Performance analysis of three phase fully controlled and semi-controlled converter for RL load for discontinuous current mode.
7	Performance analysis of single phase bridge inverter for RL load and voltage control by single pulse width modulation.
8	Performance analysis of two quadrant chopper.
9	Diode clamped multilevel inverter.
10	ZVS operation of a Synchronous buck converter.
	Course outcomes: At the end of the course the student will be able to: 1. Apply appropriate techniques to solve power electronics problem usage of modern tools. 2. Work collaboratively on multidisciplinary environment.

	Subject title : SEMINAR			
	Subject Code: EPE17	**No. of Credits : 2:0:0:0**		**No. of lecture hours/week :**
	Exam Duration :	**CIE : 30**	**SEE : 70**	**Total No. of lecture hours:**

The objective of the seminar is to inculcate self-learning, face audience confidently, enhance communication skill, involve in group discussion and present and exchange 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.

	Subject title : Mini Project / Industrial Visit /Field Work			
	Subject Code: EPE17	**No. of Credits : 2:0:0:0**		**No. of lecture hours/week :**
	Exam Duration :	**CIE**	**SEE**	**Total No. of lecture hours:**

The objective of the Mini Project / Industrial Visit /Field Work is to inculcate self-learning, to carryout mini Innovative projects/to enhance industrial /practical knowledge/ to carryout field work.

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.

	Subject title : AC AND DC DRIVES		
	Subject Code: EPE21	**No. of Credits : 4:0:0:0**	**No. of lecture hours/week : 4**

	Exam Duration : 3 hours	CIE : 30	SEE : 70	Total No. of lecture hours: 52

Course objective: In this course, students learn

1. Different Quadrant operation of Drives
2. The concept of AC/DC variable speed drives.
3. Different control methods of electrical drives.

Unit No.	Syllabus content	No. of hours
1	**Electric Drives**: Introduction – block diagram-classification of electrical drives-choice of electrical drives-fundamental torque equation- components of load torque-steady state stability.	08
2	**DC Drives**: Single Quadrant Drive: 1-Phase semi and half wave converter drives, Two quadrants 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.	12
3	**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, voltage and current source inverter fed induction motor drives, stator and rotor voltage control methods, slip energy recovery drives.	12
4	**Closed Loop Control of AC Drives**: Basic Principle of Vector Control, Direct & Indirect Vector control of Induction Motor, Stator voltage control, Slip regulation, Speed control of static Kramer's drive, Closed loop control of Synchronous Motors. Stepper Motor	10
5	**Applications of Drives:** Drive Consideration for Textile Mills, Steel Rolling Mills, Cranes and Hoist Drives and Centrifugal Pumps.	10
	Course outcome: At the end of the course, students will be able to **CO 1**: Acquainted with the knowledge of various AC/DC drives. **CO2:** Demonstrate the knowledge of different quadrant operation of AC/DC drives. **CO3:** Develop the closed loop control of Electrical Drives.	

TEXT BOOKS:

1. **Modern Power Electronics & AC Drives** - B K Bose, PHI, 2011.
2. **Electric Motor Drives** - R Krishnan, PHI, 2010
3. **Electric Drives-Concepts and Applications-** Vedam Subrahmanyam, McGraw Hill, 2nd edition, 2011.

REFERENCE BOOKS:

1. **Power Electronics- Circuits, Devices and Applications** - Muhammad H. Rashid, Pearson Prentice Hall 2010.
2. **Thyristor Control of AC Motors-** Murphy JMD, Turnbull F.G., Pergamon Press Oxford. 1998.
3. **High Performance Control of AC Drives-** MehrdadEhsani, YiminGaoAlinEmadi, Wiley, 2012.

Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 2 and Unit 3.

	Subject title : SWITCHED MODE POWER CONVERSION

	Subject Code: EPE22	No. of Credits : 4:0:0:0		No. of lecture hours/week : 4
	Exam Duration : 3 hours	CIE : 30	SEE : 70	Total No. of lecture hours: 52

Course objective: In this course, students learn

1. the operating principles of different power converters.
2. the Designing and controlling of different power converters
3. the Simulation in computer for Realization of power converters

Unit No.	Syllabus content	No. of hours
1	**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, 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, principle of operation and analysis of buck boost converter analysis, inductors current ripple and output voltage ripple, design considerations for continuous current mode operation.	12
2	Buck-boost converter for 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). **Derived 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.	10
3	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
4	**Control of DC-DC Converter:** Modeling of DC-DC converters, power supply control, control loop stability, small signal analysis, switch transfer function, filter transfer function, PWM transfer function, Type-2 error amplifier with compensation, design, PSpice simulation of feedback control, Type-3 error amplifier with compensation, design.	10
5	**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. **Design of inductor and transformers for SMPC.**	10
	Course outcome: At the end of the course, students will be able to CO 1: Analyze and distinguish the power converters CO 2: Design and control the different power converters CO 3: Simulate in computer for Realization of power converters.	

TEXT BOOKS:

1. **Power Electronics**- Daniel W Hart Tata McGraw Hil l, 2011.
2. **Power Electronics – Circuits Devices and Applications** -Rashid M.H., 3 rd Edition, Pearson, 2011.

REFERENCE BOOKS:

1. **DC-DC Switching Regulator Analysis** - D M Mitchel M cGraw-Hill Ltd, 1988.
2. **Design of Magnetic Compon ents for Switched Mode Power Converters**- Umanand L and Bhatt S R New Age International, New Delhi, 2001
3. **Power Electronics Converters, Applications, and Design**-Ned Mohan, Tore M. Undeland, William P. Robbins 3 rd Edition, Wiley India Pvt Ltd, 2010.

Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 1 and Unit 2.

Subject title : MODELING AND ANALYSIS OF ELECTRICAL MACHINES			
Subject Code: EPE23	**No. of Credits : 4:0:0:0**		**No. of lecture hours/week : 4**
Exam Duration : 3 hours	**CIE : 30**	**SEE : 70**	**Total No. of lecture hours: 52**

Course objective: In this course, student

1. understand the concept of 2-axis representation of an Electrical machine.
2. will know the concepts of representing transfer function model of a DC machine
3. understand the importance of 3-phase to 2-phase conversion
4. will know the representation of 3-phase induction motor in various reference frames

Unit No.	**Syllabus content**	**No. of hours**
1	**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. **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
2	**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. **Dynamic Modelling of Three Phase Induction Machine:** Generalized model in arbitrary frame, electromagnetic torque, deviation 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, dynamic simulation. **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.	12
3	**Transformer Modelling**: 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, auto transformers, transmission line and transformers	10
4	**Modelling 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, analysis of steady state operation.	10
5	**Dynamic Analysis of Synchronous Machines:** Dynamic performance during sudden change in input torque and during a 3-phase fault at the machine terminals, approximate transient torque versus rotor angle characteristics, comparison of actual and approximate transient torque-angle characteristics during a sudden change in input torque; first swing transient stability limit, comparison of actual and approximate transient torque-angle characteristics during a 3-phase fault at the machine terminals, critical clearing time, equal area criterion, computer simulation.	10

	Course outcome: At the end of the course, **s**tudents will be able to CO 1: Develop models for linear and nonlinear magnetic circuits CO 2: Determine the developed torque in an electrical machines using the concepts of filed energy and co-energy and determine the dynamic model of a DC Machine CO 3:Determine the dynamic model of an induction machine based on the dq transformation and determine instantaneous torque developed in an induction machine-which leads to advanced control strategies such as vector control and direct torque control.	

TEXT BOOKS:

1. **Generalized Theory of Electrical Machines -** P.S.Bimbra, 5 thEdition, Khanna Publications, 1995.
2. **Electric Motor Drives -** Modeling, Ana lysis & Control, R. Krishnan PHI Learning Private Ltd, 2009.

REFERENCE BOOKS:

1. **Analysis of Electrical Machinery and Drive Systems -** P.C.Krause, Oleg Wasynczuk, Scott D.Sudhoff,2ndEdition, Wiley(India),2010.
2. **Power System Analysis -** Arthur R Bergen and Vijay Vittal 2 nd Edition, Pearson, 2009.
3. **Power System Stability and Control -** PrabhaKundur TMH, 2010.
4. **Dynamic Simulation of Electric Machin ery using Matlab / Simulink -** Chee-MunOng Prentice Hall, 1998.

Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 2 and Unit 5.

	Subject title : FACTS CONTROLLERS			
	Subject Code: EPE24	No. of Credits : 4:0:0:0		No. of lecture hours/week : 4
	Exam Duration : 3 hours	CIE : 30	SEE : 70	Total No. of lecture hours: 52

Course objective: In this course, students learn

1. Transmission line network of power system and its control parameters.
2. Concept of compensation.
3. Different configuration of Converters and implementation of compensation.

Unit No.	Syllabus content	No. of hours
1	**Control Mechanism:** Background, Electrical Transmission Networks, Conventional Control Mechanisms, Flexible ac Transmission Systems (FACTS), Emerging Transmission Networks. **Reactive-Power Control in Electrical Power Transmission Systems:** Reactive Power, Uncompensated Transmission Lines, Passive Compensation. **Principles of Conventional Reactive-Power Compensators:** Introduction, Synchronous Condensers, The Saturated Reactor (SR), The Thyristor-Controlled Reactor (TCR), and The Thyristor-Controlled Transformer (TCT).	10
2	**Principles of Conventional Reactive-Power Compensators (continued):** The Fixed Capacitor–Thyristor-Controlled Reactor (FC–TCR), The Mechanically Switched Capacitor–Thyristor-Controlled Reactor (MSC–TCR), The Thyristor-Switched Capacitor (TSC), The Thyristor-Switched Capacitor–Thyristor- Controlled Reactor (TSC–TCR), A Comparison of Different SVCs. **SVC Voltage Control:** Introduction Voltage Control.	10
3	**SVC Voltage Control (continued):** Effect of Network Resonances on the Controller Response, The 2nd Harmonic Interaction between the SVC and ac Network, Application of the SVC to Series-Compensated ac Systems, 3rd Harmonic Distortion, Voltage-Controller Design Studies.	10
4	**4SVC Applications:** Introduction, Increase in Steady-State Power-Transfer Capacity, Enhancement of Transient Stability, Augmentation of Power-System Damping - Principle of the SVC Auxiliary Control, Torque Contributions of SVC Controllers, Effect of the Power System, Effect of the SVC,SVC Mitigation of Sub synchronous Resonance (SSR) - Principle of SVC Control, Configuration and Design of the SVC Controller, Rating of an SVC, Prevention of Voltage Instability- Principles of SVC Control- A Case Study, Configuration and Design of the SVC Controller, Rating of an SVC. **The Thyristor-Controlled Series Capacitor (TCSC):** Series Compensation, The TCSC Controller, Operation of the TCSC, The TSSC, Analysis of the TCSC, Capability Characteristics, Harmonic Performance, Losses, Response of the TCSC, Modelling of the TCSC.	12
5	**TCSC Applications:** Introduction, Open-Loop Control, Closed-Loop Control, Improvement of the System-Stability Limit, Enhancement of System Damping, Sub synchronous Resonance (SSR) Mitigation, Voltage-Collapse Prevention. **VSC based FACTS Controllers:** Introduction, The STATCOM, The SSSC, The UPFC, Comparative Evaluation of Different FACTS Controllers.	10

Course outcome:
At the end of the course, students will be able to
CO 1: Transmission line network of power system and its control parameters.
CO 2: Concept of compensation.
CO 3: Different configuration of Converters and implementation of compensation.

TEXT BOOKS:

1. **FACTS Controllers in Power Transmissi on and Distribution** - K.R Padiyar New Age International, 2007.
2. **Understanding FA CTS: Concepts and Technology of Flexible AC Transmission Systems-** Narain G Hingorani and L. Gyugyi, Wiley India, 2011.

REFERENCE BOOKS:

1. **Flexible AC Transmissi on System-** Y. H. Song and A. T. Johns Institution of Engineering and Technology, 2009.
2. **Thyristor – Based Facts Controllers for Electrical Transmission Systems-**Mohan Mathur, R., Rajiv. K. Varma IEEE press and John Wiley & Sons, Inc.

Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 1 and Unit 3.

Subject title : INTEGRATION OF RENEWABLE ENERGY				
Subject Code: EPE251	**No. of Credits : 4:0:0:0**		**No. of lecture hours/week : 4**	
Exam Duration : 3 hours	**CIE : 30**	**SEE : 70**	**Total No. of lecture hours: 52**	

Course objective: In this course, student

1. To provide knowledge about the stand alone and grid connected renewable energy systems.
2. To equip with required skills to derive the criteria for the design of power converters for renewable energy applications.
3. To analyze and comprehend the various operating modes of wind electrical generators and solar energy systems.
4. To design different power converters namely AC to DC, DC to DC and AC to AC converters for renewable energy systems.
5. To develop maximum power point tracking algorithms.

Unit No.	**Syllabus content**	**No. of hours**
1	**INTRODUCTION:** Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (Cost-GHG Emission) - Qualitative study of different renewable energy resources ocean, Biomass, Hydrogen energy systems: operating principles and characteristics of: Solar PV, Fuel cells, wind electrical systems-control strategy, operating area.	10
2	**ELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION** Review of reference theory fundamentals-principle of operation and analysis: IG, PMSG, SCIG and DFIG.	10
3	**POWER CONVERTERS** Solar: Block diagram of solar photo voltaic system: line commutated converters (inversion mode) - Boost and buck-boost converters- selection Of inverter, battery sizing, array sizing. Wind: three phase AC voltage controllers- AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, Grid Interactive Inverters-matrix converters.	12
4	**ANALYSIS OF WIND AND PV SYSTEMS** Stand alone operation of fixed and variable speed wind energy conversion systems and solar system-Grid connection Issues -Grid integrated PMSG and SCIG Based WECS-Grid Integrated solar system	10
5	**HYBRID RENEWABLE ENERGY SYSTEMS** Need for Hybrid Systems- Range and type of Hybrid systems- Case studies of Wind-PV Maximum Power Point Tracking (MPPT).	10
	Course outcome: At the end of the course, **s**tudents will be able to CO 1: Explain the environmental aspects of electric energy conversion and impacts of renewable energy. CO 2: Analyse, electrical machines for renewable energy operation CO 3: Analyse, design and construct switch mode power supply circuits (specifically the buck, boost and buck-boost converters). CO 4: Discuss and design grid connected converter systems for renewables.	

	CO 5: Describe the operational principles of wind energy conversion systems, hybrid systems and Integration of multiple renewable energy sources.	

TEXT BOOKS:

1. **Wind energy system ,** Gray, L. Johnson, Prentice hall inc., 1995.
2. **Power electronics Hand book**, Rashid .M. H.Academic press, 2001.

REFERENCE BOOKS:

1. **Wind Electricaal Systems",** S.N.Bhadra, D. Kastha, & S. Banerjee Oxford University Press, 2009
2. **Non conventional energy sources,** Rai. G.D, Khanna publishers, 1993.
3. **Solar energy utilization ,** Rai. G.D., Khanna publishera, 1993.
4. **Non-conventional Energy sources,** B.H.Khan Tata McGraw-hill Publishing Company,2nd Edition, 2009, New Delhi.

Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 3 and Unit 4.

Subject title : POWER QUALITY			
Subject Code: EPE252	**No. of Credits : 4:0:0:0**		**No. of lecture hours/week : 4**
Exam Duration : 3 hours	**CIE : 30**	**SEE : 70**	**Total No. of lecture hours: 52**

Course objective: To enable students learn

1. Use of power electronic components in power system, power quality problems and affects all connected electrical and electronic equipment.
2. Power quality problems of electrical machines and power systems

Unit No.	Syllabus content	No. of hours
1	**Introduction**, power quality-voltage quality, power quality evaluation procedures term and definitions: general classes of power quality problems, transients, long duration voltage variation, short duration voltage variations, voltage imbalance, waveform distortion, power quality terms. **Voltage sags and interruptions:** sources of sags and interruptions, estimating voltage sag performance, fundamental principles of protection, motor starting sags.	10
2	**Transient over voltages:** sources of transient over voltages, principles of over voltages protection, utility capacitor switching transients, fundamentals of harmonics: harmonic distortion, voltage versus transients, harmonic indexes, harmonic sources from commercial loads, harmonic sources from industrial loads, effects of harmonic distortion, intra-harmonics.	12
3	**Applied harmonics:** harmonic distortion evaluations, principles for controlling harmonics, harmonic studies, devices for controlling harmonic distortion, harmonic filters, standards of harmonics.	10
4	**Power quality benchmark:** introduction, benchmark process, power quality contract, power quality state estimation, including power quality in distribution planning. **Distributed generation and quality**: DG technologies, interface to utility system, power quality issues, interconnection standards.	10
5	**Power quality monitoring:** monitoring considerations, power quality measurement equipments, assessment of power quality measurement data, application of intelligent systems, power quality monitoring standards.	10
	Course outcome: At the end of the course, **s**tudents will be able to CO 1: Identify the causes and effects of power quality problems such as non-sinusoidal wave shapes, voltage outages, and harmonic losses, origins of single-time events such as voltage dips, voltage reductions, and outages. CO 2: Adopt different techniques to mitigate the power quality problems. CO 3: Have a knowledge of guidelines and standards as well as industry regulations and practices for solving power quality problems in a cost-effective manner. CO 4: Have knowledge of estimating the power quality CO 5: Monitor the power quality using different techniques	

TEXT BOOKS:

1. **Electric Power Quality -** Dugan, Roger C, Santoso, Surya, McGraw-Hill professional publication, 2003
2. **Electric Power Quality** - G.T.Heydt **,** stars in a circle publications, 1991

REFERENCE BOOKS:

1. **Modern Power Electronics-**M.H.Rashid, TATA McGraw Hill, 2001
2. **Understanding power quality problems voltage sags and interruptions -** Math H. J. Bollen, IEEE Press, 2000
3. **Power quality in power systems and electrical machines**- Ewald F Fuchs, Mohammad A.S., Masoum, Elsevier, 2009

Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 1 and Unit 2.

Subject title : ELECTRIC VEHICLE TECHNOLOGY				
Subject Code: EPE253	**No. of Credits : 4:0:0:0**		**No. of lecture hours/week : 4**	
Exam Duration : 3 hours	**CIE : 30**	**SEE : 70**	**Total No. of lecture hours: 52**	

Course objective: To enable students to know the

1. Advantages of EVs.
2. Various drive trains
3. Characteristics of various types of batteries.
4. Concept of hybrid electric vehicles

Unit No.	Syllabus content	No. of hours
1	**Introduction to electric vehicles (EVs):**Historical perspective. EV advantages and impacts. EVmarket and promotion: infrastructure needs, legislation and regulation, standardization. **Electric vehicle (EV) design options:** EV con figurations: fixed vs. variable gearing, single- vs. multiple-motor drive, in-wheel drives. EV parameters, driving cycles and performance specifications. Choice of system voltage levels: electrical safety and protection.	10
2	**Vehicle dynamics and motor drives:** Road load: vehicle kinetics; effect of velocity, acceleration and grade. EV drive train and components. EV motor drive systems: DC drives, induction motor drives, permanent-magnet synchronous motor drives, switched reluctance motor drives. Control strategies.	10
3	**Batteries:** Battery parameters. Types and characteristics of EV batteries. Battery testing and maintenance; charging schemes. Battery monitoring techniques. Open-circuit voltage and ampere- hour estimation. Battery load levelling	10
4	**Emerging EV technologies:** Hybrid electric vehicles (HEVs): types, operating modes, torque coordination and control, generator/motor requirements.	10
5	**Fuel cell electric vehicles (FEVs):** Fuel cell characteristics, hydrogen storage systems, reformers. Alternative sources of power: super- and ultra- capacitors, flywheels.	10
	Course outcome: At the end of the course, **s**tudents will be able to CO 1: Describe the configuration of a typical electric vehicle CO 2: Differentiate among different drive trains. CO 3: Understand the limitations and advantages of various battery chemistries. CO 4: Develop strategies for charging various types of batteries. CO 5: Describe the various drive trains of hybrid electric vehicles.	

TEXT BOOKS:

1. **Modern Electric Vehicle Technology**- C.C. Chan and K.T. Chau,Oxford University Press, London
2. **Electric and Hybrid Vehicles**: Iqbal Husain- New York: CRC Press.

REFERENCE BOOKS:

4. **Modern Electric, Hybrid Electric, and Fuel C ell Vehicles:** Fundamentals, Theory and Design**-** M. Ehsani, Y. Gao, S .E. Gay and A. Emadi, **-** New York: CRC Press
5. **Web address-** Batteryuniversity.com

Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 1 and Unit 3.

	Subject title : HVDC POWER TRANSMISSION			
	Subject Code: EPE41	**No. of Credits: 4:0:0:0**		**No. of lecture hours/week : 4**
	Exam Duration : 3 hours	**CIE : 30**	**SEE : 70**	**Total No. of lecture hours: 52**

Course objective: In this course, students learn

- DC power transmission and the basic components of a converter, the methods for compensating the reactive power demanded by the converter and the methods for simulation of HVDC systems.
- The types of filters and the characteristics of the system impedance resulting from AC filter designs and different methods of control of HVDC converter and system.
- The design techniques for the main components of an HVDC system.
- The protection of HVDC system and other converter configurations used for the HVDC transmission and the recent trends for HVDC applications.

Unit No.	Syllabus content	No. of hours
1	**DC Power Transmission Technology:** Introduction, comparison with AC transmission, application of DC transmission, description of DC transmission system, Planning of HVDC transmission, modern trends in DC transmission, operating problems. **HVDC Converters**: Introduction to Line commutated converter, choice of converter configuration for any pulse number, analysis of 6 and 12 pulse Graetz bridge converter without overlap, effect of smoothing reactor. Two and Three level voltage source converters, Pulse Width Modulation. Analysis of converter in two and three, and three and four valve conduction modes, LCC bridge characteristics, Twelve pulse converter, detailed analysis of converters. Analysis of Capacitor Commutated and voltage source converters.	12
2	**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. Control of voltage source converter. **Converter Faults and Protection:** Converter faults, protection against over currents, over voltages in converter station, surge arrestor, protection against over voltages. Protection against faults in voltage source converter.	10
3	**Converter Configurations for HVDC Transmission**: Introduction, Voltage Source Converter (VSC), CCC and CSCC HVDC System, 10.4 Multi-Terminal DC Transmission. **Trends for HVDC Applications:** Wind Farm Technology, Modern Voltage Source Converter (VSC) HVDC Systems, 800 kV HVDC System.	10
4	**Harmonics and Filters:** Introduction, Generation of harmonics, design of AC and DC filters. **Power Flow Analysis in AC/DC Systems**: Introduction, dc system model, solution procedure, inclusion of constraints, case study, on line power flow analysis for security control, power flow analysis under dynamic conditions, power flow with VSC based HVDC system.	10
5	**Stability Analysis and Power Modulation:** Introduction to stability concepts, power modulation, practical considerations in the application of modulation controllers, voltage stability, analysis of voltage stability in asynchronous AC/DC system. **Multi Terminal DC Systems**: Introduction, applications, types, control and protection.	10

Course outcomes:

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

- Explain the importance of DC power transmission, the basic components of a converter and methods for compensating the reactive power.
- Explain the methods for simulation of HVDC systems and its control.
- Design filters for eliminating harmonics.
- Explain the design techniques for the main components of an HVDC system.
- Analyse the protection of HVDC system and other converter configurations used for the HVDC transmission.
- Describe the recent trends for HVDC applications.

REFERENCE BOOKS:

1. Chan-Ki Kim et al " HVDC Transmission: Power Conversion Applications in Power Systems" Wiley, 2009
2. K. R. Padiyar, "HVDC Power Transmission Systems", New Age International, 2012.
3. E.W.Kimbark "Direct Current Transmission", Vol.1, Wiley Inter-Science, London, 2006.
4. Arrilaga, "High Voltage Direct Current Transmission", The Institute of Engineering and Technology, 2nd Edition, 2007.
5. S Kamakshaiah and V Kamaraju, "HVDC Transmission", TMH, 2011.
6. Vijay K Sood, "HVDC and FACTs Controllers; Applications of Static Converters in Power Systems, BSP Books Pvt.Ltd.,First Indian reprint 2013.

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Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 1 and Unit 2.

Subject title : MPPT IN SOLAR SYSTEMS				
Subject Code: EPE421	**No. of Credits : 4:0:0:0**		**No. of lecture hours/week : 4**	
Exam Duration : 3 hours	**CIE : 30**	**SEE : 70**	**Total No. of lecture hours: 52**	

Course objective: In this course, students learn

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

Unit No.	Syllabus content	No. of hours
1	**PV Modelling:** 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 Modelling 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
2	**Maximum Power Point Tracking (continued):** Improvements of the P&O Algorithm, Evolution of the Perturbative Method, PV MPPT via Output Parameters, MPPT Efficiency. **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.	12
3	**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
4	**Distributed Maximum Power Point Tracking of Photovoltaic Arrays (continued):** AC Analysis of a PV Array with DMPPT.	10
5	**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.	10

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

- Explain the PV cell characteristics and its model, equivalent circuits and circuit parameter calculations.
- Describe 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.
- Implement high energy efficiency power converters for PV MPPT application.

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

Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 1 and Unit 2.

Subject title : PWM CONVERTERS AND APPLICATIONS (ELECTIVE- III)				
Subject Code: EPE422	**No. of Credits : 4:0:0:0**		**No. of lecture hours/week : 4**	
Exam Duration : 3 hours	**CIE : 30**	**SEE : 70**	**Total No. of lecture hours: 52**	

Course objective: In this course, students learn

- AC/DC and DC/AC Power Conversion
- Different PWM Techniques
- Computation of switching Losses.
- Dynamic Modelling of PWM converters
- Different compensation techniques.

Unit No.	Syllabus content	No. of hours
1	**AC/DC and DC/AC Power Conversion:** Overview of applications of voltage source converters.	10
2	**PWM Techniques:** Pulse modulation techniques for I – phase bridges, bus clamping PWM, space vector based PWM, advanced PWM techniques.	10
3	**Loss Calculations:** Practical devices in converters, calculation of switching and conduction losses, compensation for dead time and DC voltage regulation.	12
4	**Modelling:** Dynamic model of PWM converters; constant V/F induction motor drives; estimation of current ripple and torque ripple in inverter fed drives.	10
5	**Converters with Compensation:** Line-side converters with power factor compensation, reactive power compensation, harmonic current compensation.	10

Course outcomes:

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

- Explain the applications of AC/DC and DC/AC Power Conversion.
- Analyse different PWM Techniques
- Compute switching and conduction losses.
- Implement dynamic modeling of PWM converters
- Discuss different compensation techniques.

REFERENCE BOOKS:

1. Mohan, Undeland and Robbins, "Power Electronics: Co nverter, Applications and Design", Wiley India, 201 1.
2. Erickson RW, "Fundamentals of Power Electronics", C hapman Hall, 1997.
3. Joseph Vithyathil, "Power Electronics- Principles a nd Applications", TMH, 2011.

Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 3 and Unit 5.

	Subject title : DSP APPLICATIONS TO DRIVES			
	Subject Code: EPE423	**No. of Credits : 4:0:0:0**		**No. of lecture hours/week : 4**
	Exam Duration : 3 hours	**CIE : 30**	**SEE : 70**	**Total No. of lecture hours: 52**

Course objective: In this course, students learn

- DSP controller, CPU architecture and instruction set.
- DSP-Based Applications.
- DSP-based vector control of induction motors.

Unit No.	Syllabus content	No. of hours
1	**Introduction:** To the TMS320LF2407 DSP Controller, C2xx DSP CPU architecture and instruction set. General Purpose Input/output (GPIO) functionality interrupts on the TMS320LF2407.	10
2	Analog-to-Digital Converter (ADC), event managers (EVA, EVB). **DSP-Based Applications:** Of DC-DC buck-boost converters, DSP based control of stepper motors,	12
3	DSP-Based control of permanent magnet brushless DC machines, Park and Clarke's transformations.	10
4	Space Vector Pulse Width Modulation, DSP-based control of permanent magnet synchronous machines.	10
5	**DSP-based vector control of induction motors**.	10

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

- Explain DSP controller, CPU architecture and to write instruction set for specific task.
- Implement DSP for specific Applications.
- Implement DSP-based vector control of induction motors.

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”, 2 nd Edition, Wiley India,2010
3. Chee-Mun Ong, “Dynamic Simulation of Electric Machinery using Matlab / Simulink”, Prentice Hall,1998.

Note: One question of 20 marks from each unit. Internal Choices must be provided in Unit 2 and Unit4.