Dr. Ambedkar Institute of Technology

Department of Electrical and Electronics Engineering

The NAAC documents enclosed are verified and approved.

5/11/22

HOD

Dept of EEE

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

Panchajanya Vidya Peetha Welfare Trust (Regd)

Dr. Ambedkar Institute of Technology

Aided by Govt. of Karnataka, An Autonomous Institution, Affiliated to Visvesvaraya Technological University, Belagavi,
Approved by All India Council for Technical Education (AICTE), New Delhi, Accredited by NBA and NAAC with 'A' Grade

BDA Outer Ring Road, Mallathahalli, Bengaluru - 560 056

Ref. No. .....

Date : 05.01.2023

2021-22

Subjects focusing on Employability/Entrepreneurship/Skill development for the year

Sl No	Subject Code	Subject title	Mapped to Employability/Entrepreneur/Skill
1.	20EPE12	Power Semiconductor Devices and Components	Employability
2.	20EPE13	Solid State Power Controllers	Employability
3.	20EPE14	Modelling and Simulation of Power Electronics Systems	Entrepreneur
4.	20EPE151	Embedded Systems	Skill
5.	20EPE152	Advanced Control Systems	Skill
6.	20EPE161	PWM converters and applications	Employability
7.	20EPE162	MPPT in solar systems	Employability
8.	20EPE163	Electric Vehicle Technology	Entrepreneur
9.	20EPEL17	Power Electronics Laboratory-1	Skill
10.	20EPE21	AC and DC Drives	Skill
11.	20EPE22	Switched Mode Power Conversion	Employability
12.	20EPE23	Power Electronics System Design Using Linear ICs	Skill
13.	20EPE24	HVDC power Transmission	Employability
14.	20EPE263	DSP applications to drives	Skill

BOS Chairman

Principal

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 : 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**"1stedition 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

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, 2nd Edition, 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 : 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

Panchajanya Vidya Peetha Welfare Trust (Regd)

Dr. Ambedkar Institute of Technology

Aided by Govt. of Karnataka, An Autonomous Institution, Affiliated to Visvesvaraya Technological University, Belagavi,
Approved by All India Council for Technical Education (AICTE), New Delhi, Accredited by NBA and NAAC with 'A' Grade
BDA Outer Ring Road, Mallathahalli, Bengaluru - 560 056

Ref. No. .....

Date : 05.01.2023

2020-21

Subjects focusing on Employability/Entrepreneurship/Skill development for the year

Sl No	Subject Code	Subject title	Mapped to Employability/Entrepreneur/Skill
15.	20EPE12	Power Semiconductor Devices and Components	Employability
16.	20EPE13	Solid State Power Controllers	Employability
17.	20EPE14	Modelling and Simulation of Power Electronics Systems	Entrepreneur
18.	20EPE151	Embedded Systems	Skill
19.	20EPE152	Advanced Control Systems	Skill
20.	20EPE161	PWM converters and applications	Employability
21.	20EPE162	MPPT in solar systems	Employability
22.	20EPE163	Electric Vehicle Technology	Entrepreneur
23.	20EPEL17	Power Electronics Laboratory-1	Skill
24.	20EPE21	AC and DC Drives	Skill
25.	20EPE22	Switched Mode Power Conversion	Employability
26.	20EPE23	Power Electronics System Design Using Linear ICs	Skill
27.	20EPE24	HVDC power Transmission	Employability
28.	20EPE263	DSP applications to drives	Skill

BOS Chairman

Principal

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 : 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**"1stedition 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

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, 2nd Edition, 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 : 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

Panchajanya Vidya Peetha Welfare Trust (Regd)

Dr. Ambedkar Institute of Technology

Aided by Govt. of Karnataka, An Autonomous Institution, Affiliated to Visvesvaraya Technological University, Belagavi,
Approved by All India Council for Technical Education (AICTE), New Delhi, Accredited by NBA and NAAC with 'A' Grade
BDA Outer Ring Road, Mallathahalli, Bengaluru - 560 056

Ref. No. .....

Date : 05.01.2022

2019-20

Subjects focusing on Employability/Entrepreneurship/Skill development for the year

Sl No	Subject Code	Subject title	Mapped to Employability/Entrepreneur/Skill
1.	18EPE12	Power Semiconductor Devices and Components	Employability
2.	18EPE13	Solid State Power Controllers	Employability
3.	18EPE14	Modelling and Simulation of Power Electronics Systems	Entrepreneur
4.	18EPE151	Embedded Systems	Skill
5.	18EPE152	Advanced Control Systems	Skill
6.	18EPEL16	Power Electronics Laboratory-1	Skill
7.	18EPE21	AC and DC Drives	Skill
8.	18EPE22	Switched Mode Power Conversion	Employability
9.	18EPE23	Power Electronics System Design Using Linear ICs	Skill
10.	18EPE253	Electric Vehicle Technology	Entrepreneur
11.	18EPE41	HVDC power Transmission	Employability
12.	18EPE421	MPPT in solar systems	Employability
13.	18EPE422	PWM converters and applications	Employability
14.	18EPE423	DSP applications to drives	Skill

BOS Chairman

Principal

	Subject title : POWER SEMICONDUCTOR DEVICES AND COMPONENTS			
	Subject Code: 18EPE12	**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, 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 and 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, 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.	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, snubber circuits for thyristors, need for snubbers with transistors, turn-off snubber, overvoltage snubber, turn-on snubber, snubbers for bridge circuit configurations, GTO	10

	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: 18EPE13	**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, 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 SYSTEMS			
	Subject Code: 18EPE14	**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, 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, students 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: 18EPE151	**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, 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. **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.	10
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 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 ,	10

	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.	
	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 : ADVANCED CONTROL SYSTEMS			
	Subject Code: 18EPE152	**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, 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 and Aliasing, Reconstruction of Analog Signals, Practical Aspects of the choice of Sampling Rate, Principle of Discretization.	10
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,	10

	System Analysis on the Phase Plane, Simple Variable Structure Systems, Lyapunov Stability Definitions, Lyapunov Stability Theorems, Lyapunov Functions for Nonlinear Systems	
	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 : POWER ELECTRONICS LABORATORY-I			
	Subject Code: 18EPEL16	**No. of Credits : 2:0:0:0**		**No. of lecture hours/week : 3**
	Exam Duration : 3 hours	**CIE : 50**	**SEE : 50**	**Total No. of lecture hours: 39**

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 using modern tools. 2. Work collaboratively on multidisciplinary environment.

	Subject title : AC AND DC DRIVES			
	Subject Code: 18EPE21	**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

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: 18EPE22	**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

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 : POWER ELECTRONICS SYSTEM DESIGN USING LINEAR ICs			
	Subject Code: 18EPE23	**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: To enable students learn

1. To explain basic and necessary requirements for designing a regulator circuit.
2. To discuss various types of PWM ICs used for designing regulator circuits.
3. To introduce and explain basics of PLC and programming of PLC.

Unit No.	Syllabus content	No. of hours
1	**Introduction**: Measurement techniques for voltages, current, power, power factor in power electronic circuits, other recording and analysis of waveforms, sensing of speed	10
2	**Switching Regulator Control Circuits:** Introduction, isolation techniques of switching regulator systems, PWM systems.	10
3	**Commercial PWM Control ICs and their Applications:** TL 494 PWM control IC, UC 1840 programmable off line PWM controller, UC 1524 PWM control IC, UC 1846 current mode control IC, UC 1860 resonant mode power supply controller. Switching power supply ancillary, supervisory & peripheral circuits and components: introduction, optocouplers, self-biased techniques used in primary side of reference power supplies, soft/start in switching power supplies.	12
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 ICs, 555 timer & its applications, analog to digital converter using IC's, digital to analog converters using ICs, implementation of different gating circuits. Various ADC and DAC circuits.	10
5	**Programmable Logic Controllers (PLC):** Basic configuration of a PLC, programming and PLC, program modification, power converter control using PLCs. ICs for Switch-Mode Power Supplies: Control ICs for Switch mode power supplies, IC timers as controllers for switch-mode power supplies.	10
	Course outcome: At the end of the course, students will be able to CO 1: identify Types of measuring instruments required in PE circuits. CO 2: Detailed methods of protection & isolation requirements CO 3: Different ICs available for various purposes (PWM generation, protection etc). CO 4: Basics of PLC and basic programming methods of PLC	

TEXT BOOKS:

1. "**Thyristorised Power Controllers**", G. K. Dubey, S. R. Doradla, A. Johsi, and R. M. K. Sinha, 2ndEdition, New Age International, 2010.
2. "**High Frequency Switching Power Supplies**", Chryssis, 2nd Edition, MGH, 1989.
3. Unitrode application notes: http://www.smps.us/Unitrode.html

REFERENCE BOOKS:

1. **"Switch- Mode Power Supply Design",** P.R.K. Chetty, BPB Publications.

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

	Subject title : ELECTRIC VEHICLE TECHNOLOGY			
	Subject Code: 18EPE253	**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

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. EV market 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:

1. **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
2. **Web address**- Batteryuniversity.com

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

Panchajanya Vidya Peetha Welfare Trust (Regd)

Dr. Ambedkar Institute of Technology

Aided by Govt. of Karnataka, An Autonomous Institution, Affiliated to Visvesvaraya Technological University, Belagavi,
Approved by All India Council for Technical Education (AICTE), New Delhi, Accredited by NBA and NAAC with 'A' Grade
BDA Outer Ring Road, Mallathahalli, Bengaluru - 560 056

Ref. No. .....

Date : 05.01.2023

2018-19

Subjects focusing on Employability/Entrepreneurship/Skill development for the year

Sl No	Subject Code	Subject title	Mapped to Employability/Entrepreneur/Skill
1.	18EPE12	Power Semiconductor Devices and Components	Employability
2.	18EPE13	Solid State Power Controllers	Employability
3.	18EPE14	Modelling and Simulation of Power Electronics Systems	Entrepreneur
4.	18EPE151	Embedded Systems	Skill
5.	18EPE152	Advanced Control Systems	Skill
6.	18EPEL16	Power Electronics Laboratory-1	Skill
7.	18EPE21	AC and DC Drives	Skill
8.	18EPE22	Switched Mode Power Conversion	Employability
9.	18EPE23	Power Electronics System Design Using Linear ICs	Skill
10.	18EPE253	Electric Vehicle Technology	Entrepreneur
11.	18EPE41	HVDC power Transmission	Employability
12.	18EPE421	MPPT in solar systems	Employability
13.	18EPE422	PWM converters and applications	Employability
14.	18EPE423	DSP applications to drives	Skill

BOS Chairman

Principal

	Subject title : POWER SEMICONDUCTOR DEVICES AND COMPONENTS			
	Subject Code: 18EPE12	**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, 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 and 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, 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.	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, snubber circuits for thyristors, need for snubbers with transistors, turn-off snubber, overvoltage snubber, turn-on snubber, snubbers for bridge circuit configurations, GTO	10

	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: 18EPE13	**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, 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 SYSTEMS			
	Subject Code: 18EPE14	**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, 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, students 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: 18EPE151	**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, 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. **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.	10
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 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 ,	10

	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.	
	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 : ADVANCED CONTROL SYSTEMS			
	Subject Code: 18EPE152	**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, 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 and Aliasing, Reconstruction of Analog Signals, Practical Aspects of the choice of Sampling Rate, Principle of Discretization.	10
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,	10

	System Analysis on the Phase Plane, Simple Variable Structure Systems, Lyapunov Stability Definitions, Lyapunov Stability Theorems, Lyapunov Functions for Nonlinear Systems	
	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 : POWER ELECTRONICS LABORATORY-I			
	Subject Code: 18EPEL16	**No. of Credits : 2:0:0:0**		**No. of lecture hours/week : 3**
	Exam Duration : 3 hours	**CIE : 50**	**SEE : 50**	**Total No. of lecture hours: 39**

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 using modern tools. 2. Work collaboratively on multidisciplinary environment.

	Subject title : AC AND DC DRIVES			
	Subject Code: 18EPE21	**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

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: 18EPE22	**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

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 : POWER ELECTRONICS SYSTEM DESIGN USING LINEAR ICs			
	Subject Code: 18EPE23	**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: To enable students learn

1. To explain basic and necessary requirements for designing a regulator circuit.
2. To discuss various types of PWM ICs used for designing regulator circuits.
3. To introduce and explain basics of PLC and programming of PLC.

Unit No.	Syllabus content	No. of hours
1	**Introduction**: Measurement techniques for voltages, current, power, power factor in power electronic circuits, other recording and analysis of waveforms, sensing of speed	10
2	**Switching Regulator Control Circuits:** Introduction, isolation techniques of switching regulator systems, PWM systems.	10
3	**Commercial PWM Control ICs and their Applications:** TL 494 PWM control IC, UC 1840 programmable off line PWM controller, UC 1524 PWM control IC, UC 1846 current mode control IC, UC 1860 resonant mode power supply controller. Switching power supply ancillary, supervisory & peripheral circuits and components: introduction, optocouplers, self-biased techniques used in primary side of reference power supplies, soft/start in switching power supplies.	12
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 ICs, 555 timer & its applications, analog to digital converter using IC's, digital to analog converters using ICs, implementation of different gating circuits. Various ADC and DAC circuits.	10
5	**Programmable Logic Controllers (PLC):** Basic configuration of a PLC, programming and PLC, program modification, power converter control using PLCs. ICs for Switch-Mode Power Supplies: Control ICs for Switch mode power supplies, IC timers as controllers for switch-mode power supplies.	10
	Course outcome: At the end of the course, students will be able to CO 1: identify Types of measuring instruments required in PE circuits. CO 2: Detailed methods of protection & isolation requirements CO 3: Different ICs available for various purposes (PWM generation, protection etc). CO 4: Basics of PLC and basic programming methods of PLC	

TEXT BOOKS:

1. "**Thyristorised Power Controllers**", G. K. Dubey, S. R. Doradla, A. Johsi, and R. M. K. Sinha, 2ndEdition, New Age International, 2010.
2. "**High Frequency Switching Power Supplies**", Chryssis, 2nd Edition, MGH, 1989.
3. Unitrode application notes: http://www.smps.us/Unitrode.html

REFERENCE BOOKS:

1. **"Switch- Mode Power Supply Design",** P.R.K. Chetty, BPB Publications.

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

	Subject title : ELECTRIC VEHICLE TECHNOLOGY			
	Subject Code: 18EPE253	**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

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. EV market 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:

1. **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
2. **Web address**- Batteryuniversity.com

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

Panchajanya Vidya Peetha Welfare Trust (Regd)

Dr. Ambedkar Institute of Technology

Aided by Govt. of Karnataka, An Autonomous Institution, Affiliated to Visvesvaraya Technological University, Belagavi,
Approved by All India Council for Technical Education (AICTE), New Delhi, Accredited by NBA and NAAC with 'A' Grade
BDA Outer Ring Road, Mallathahalli, Bengaluru - 560 056

Ref. No. .....

Date : 05.01.2023

2017-18

Subjects focusing on Employability/Entrepreneurship/Skill development for the year

Sl No	Subject Code	Subject title	Mapped to Employability/Entrepreneur/Skill
1.	EPE12	Power Semiconductor Devices and Components	Employability
2.	EPE13	Solid State Power Controllers	Employability
3.	EPE14	Modelling and Simulation of Power Electronics.	Entrepreneur
4.	EPE151	Embedded Systems	Skill
5.	EPE153	Advanced Control Systems	Skill
6.	EPEL16	Power Electronics Laboratory-1	Skill
7.	EPE21	AC and DC Drives	Skill
8.	EPE22	Switched Mode Power Conversion	Employability
9.	EPE23	Modelling and Analysis of Electrical Machines	Employability
10.	EPE253	Electric Vehicle Technology	Entrepreneur
11.	EPE41	HVDC power Transmission	Employability
12.	EPE421	MPPT in solar systems	Employability
13.	EPE422	PWM converters and applications	Employability
14.	EPE423	DSP applications to drives	Skill

BOS Chairman

Principal

	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, 3rdEdition,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.

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, 3rdEdition,2008.

REFERENCE BOOKS

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

	Subject title : POWER ELECTRONICS LABORATORY-I			
	Subject Code: EPEL16	**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

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: 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 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.

	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 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 : 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
1.
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.

1.

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.