DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

GOVERNMENT COLLEGE OF ENGINEERING, SALEM – 636 011.

(An Autonomous Institution Affiliated to Anna University)

Regulations - 2022

Curriculum and Syllabus

M.E. Power Electronics and Drives – Full Time

Course code	Name of the Course	Category	Hours / Week				Credit	Maximum Marks		
			Lecture	Tutorial/Demo	Practical	Total Contact Periods		CA	FE	Total
SEMESTER I										
22PE**C**11	Power Semiconductor Devices and Components	PC	3	0	0	3	3	40	60	100
22PE**C**12	Analysis of Power Converters	PC	3	0	0	3	3	40	60	100
22PE**E**1X	Elective-I	PE	3	0	0	3	3	40	60	100
22PE**E**2X	Elective-II	PE	3	0	0	3	3	40	60	100
22PE**C**13	Advanced Power Electronics Laboratory	PC	0	0	4	4	2	60	40	100
22PE**C**14	Advanced Digital Control Laboratory	PC	0	0	4	4	2	60	40	100
22**MLC01**	Research Methodology and IPR	MLC	3	0	0	3	3	40	60	100
22ACXX	Audit Course 1	AC	2	0	0	2	0	100	0	100
TOTAL							**19**			**800**
SEMESTER II										
22PE**C**21	Modelling and Analysis of Electrical Machines	PC	3	0	0	3	3	40	60	100
22PE**C**22	Modern Electrical Drives	PC	3	0	0	3	3	40	60	100
22PE**E**3X	Elective-III	PE	3	0	0	3	3	40	60	100
22PE**E**4X	Elective-IV	PE	3	0	0	3	3	40	60	100
22PE**C**23	Power Electronics for Renewable Energy System Laboratory	PC	0	0	4	4	2	60	40	100
22PE**C**24	Advanced Electrical Drives Laboratory	PC	0	0	4	4	2	60	40	100
22PE**C**25	Mini Project With Seminar	EEC	0	0	4	4	2	60	40	100
22ACXX	Audit Course 2	AC	2	0	0	2	0	100	0	100
TOTAL							**18**			**800**
SEMESTER III										
22PE**E**5X	Elective – V	PE	3	0	0	3	3	40	60	100
22PE**E6**X	Elective - VI	PE	3	0	0	3	3	40	60	100
22PE**C**31	Dissertation Phase – I	EEC	0	0	20	20	10	80	120	200

TOTAL							**16**			**400**
SEMESTER IV										
22PE**C**41	Dissertation Phase – II	EEC	0	0	32	32	16	160	240	400
TOTAL							**16**			**400**

Total Credits for the Programme = 19 + 18 + 16 + 16 = 69

List of Programme Electives:

Course Code	Name of Course
Elective I	
22PE**E**11	Advanced Microcontroller Based System Design
22PE**E**12	Applied Mathematics for Electrical Engineering
22PE**E**13	System Theory
22PE**E**14	Artificial Intelligence and Machine Learning
22PE**E**15	Digital Control System
Elective II	
22PE**E**21	Advanced Power Electronic Circuits
22PE**E**22	Applied Digital Control for Power Electronics
22PE**E**23	Modern Rectifiers and Resonant Converters
22PE**E**24	Modulation Control for Power Converters
22PE**E**25	Design of Power Converters
Elective III	
22PE**E**31	Advanced Power Quality
22PE**E**32	Harmonics and Filters for Power Electronic Circuits
22PE**E**33	Energy Conservation, Auditing and Management
22PE**E**34	Special Electrical Machines and Drives
22PE**E**35	Digital Simulation of Power Electronics System
22PE**E**36	Modeling of Switched Mode Power Converters
Elective – IV	
22PE**E**41	Solar Photo Voltaic System

22PE**E**42	Optimization Techniques
22PE**E**43	Dynamics of Power Converters
22PE**E**44	Wind Energy Conversion System
22PE**E**45	Power Electronics for Renewable Energy System
Elective –V	
22PE**E**51	Smart Grid Technology
22PE**E**52	Distributed Generation and Micro Grid
22PE**E**53	FACTS Controllers
22PE**E**54	HVDC Transmission Systems
22PE**E**55	SCADA Systems and Applications
Elective –VI	
22PE**E**61	Electric Vehicles and Power Management
22PE**E**62	Grid Integration of Renewable Energy Sources
22PE**E**63	Energy Storage Technologies
22PE**E**64	Internet of Things for Smart System
22PE**E**65	Digital Signal Processors for Power Converters

List of Audit Courses:

Course Code	**Name of Course**
22AC01	English for Research paper writing
22AC02	Disaster Management
22AC03	Sanskrit for Technical Knowledge
22AC04	Value Education
22AC05	Constitution of India
22AC06	Pedagogy Studies
22AC07	Stress Management by Yoga
22AC08	Personality Development through Life Enlightenment Skills

SUMMARY

M.E – POWER ELECTRONICS AND DRIVES						
Sl. No.	SUBJECT AREA	CREDITS PER SEMESTER				CREDITS TOTAL
		I	II	III	IV	
1	Professional Core (PC) course	10	10	0	0	20
2	Professional Elective (PE) course	6	6	6	0	18
3	Employability Enhancement Course (EEC)	0	2	10	16	28
4	Mandatory Learning Course (MLC)	3	0	0	0	3
5	Audit / Zero Credit (AC) Course	√	√	0	0	0
TOTAL		19	18	16	16	69

22PEC11	**POWER SEMICONDUCTOR DEVICES AND COMPONENTS**		**SEMESTER I**			
PREREQUISITES		**CATEGORY**	**PC**	**Credit**		**3**
Power Electronics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To understand the concepts of various power semiconductor devices and their thermal behavior.
2.	To design magnetic and passive components for specific requirements.

UNIT I	**POWER SEMICONDUCTOR SWITCHES**	**9**	**0**	**0**	**9**

Introduction – Ideal power device characteristics – Typical power switching waveforms – Construction and characteristics of various power semiconductor devices – Power Diode, MOSFET, IGBT, Thyristor, GTO – Gate drive circuits for power semiconductor switches – Emerging power semiconductor devices.

UNIT II	**THERMAL ANALYSIS OF POWER SEMICONDUCTOR DEVICES**	**9**	**0**	**0**	**9**

Introduction – Cooling and Heat sinks – Thermal modeling of power switching devices – Electrical equivalent thermal model – Mathematical thermal equivalent circuit – Coupling of Electrical and Thermal components – Heat sink design – Zero voltage Switching and Zero Current switching – Basic concept and model of switching circuits.

UNIT III	**DESIGN OF MAGNETIC COMPONENTS**	**9**	**0**	**0**	**9**

Introduction – Soft magnetic material types – Comparison of material types – Ferrite Characteristics – Transformer Design – Ferrite voltage transformer – Ferrite current transformer – Design and requirements.

UNIT IV	**DESIGN OF INDUCTORS**	**9**	**0**	**0**	**9**

Introduction – Linear Inductors and chokes – Design with Hanna curves – Design including copper losses – Saturable Inductor design – Analysis of specific Inductor Design – Inductor design procedure.

UNIT V	**DESIGN OF CAPACITORS**	**9**	**0**	**0**	**9**

Introduction – General properties – Liquid and solid metal oxide dielectric capacitors – Plastic film dielectric capacitors – EMI suppression capacitors – Ceramic dielectric capacitors – Mica dielectric capacitors.

Total (45L+0T)= 45 Periods

References:

1.	Rashid M.H., “Power Electronics: Circuits, Devices and Applications", Pearson Education., 3rd Edition, 2013.
2.	Barry W. Williams, “Principles and Elements of Power Electronics: Devices, Drivers, Applications, and Passive components”, Macmillan Publishers, 2006.
3.	Mohan, Net al. “Power Electronics: Converters, Application and Design”, Wiley India (P) Ltd, New Delhi, 2007.
4.	Robert Perret, “Power Electronics Semiconductor Devices”, Wiley Publications, France, 2005.
5.	Jayant Baliga, “Advanced High Voltage Power Device Concepts”, Springer Publications, 2011.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Recall the overview of power semiconductor switches	L1: Remembering
CO2	:	Analyze the thermal requirements of power semiconductor devices	L4: Analyzing
CO3	:	Discuss the basic concepts of ZVS and ZCS	L2: Understanding
CO4	:	Evaluate the design aspects of various magnetic components according to specific requirements.	L5: Evaluating
CO5	:	Develop the design concepts of circuit elements	L4: Analyzing

COURSE ARTICULATION MATRIX

COs/ POs	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO1 0	PO1 1	PSO 1	PSO 2	PSO3
CO1	1	3	1	1	1	1	3	1	1	1	1	1	3	1
CO2	1	1	3	3	1	1	3	1	1	2	1	1	1	2
CO3	1	1	2	2	2	1	1	1	1	3	1	1	1	2
CO4	2	3	2	3	3	1	2	2	1	2	2	2	3	1
CO5	2	2	3	2	3	1	2	3	1	2	2	2	2	2
Avg.	1.40	2.00	2.20	2.20	2.00	1	2.20	1.60	1	2.00	1.40	1.40	2.00	1.60

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

22PEC12	ANALYSIS OF POWER CONVERTERS			SEMESTER I			
PREREQUISTIES		**CATEGORY**		**PC**	**Credit**		**3**
Electron Devices and Circuits, Power Electronics		**Hours/Week**		**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

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

UNIT I	**SINGLE PHASE AND THREE PHASE AC TO DC CONVERTERS**	**9**	**0**	**0**	**9**
Single phase and three phase ac to dc converters - Half controlled and Fully controlled converters semi converters with RL, RLE loads, with and without free-wheeling diodes - Continuous and discontinuous modes of operation - Output general expressions - Dual Converter – performance parameters - effect of source and load inductances and overlap- Power factor improvement techniques- Generation of Gating Sequence. Reactive power and power balance in converter circuits.					
UNIT II	**DC TO DC CONVERTERS**	**9**	**0**	**0**	**9**
Non-Isolated DC-DC Converters-Buck converter –Boost converter -Buck-Boost converter -Cuk converter- CCM and DCM operation –Output Voltage ripple - Limitations of Single stage conversion - Isolated DC-DC Converters - Flyback converters - Forward converters - Push-Pull converters- Full bridge converters–Current mode and Voltage mode control - Design of Snubbers.					
UNIT III	**SINGLE PHASE INVERTERS AND POWER CONDITIONERS**	**9**	**0**	**0**	**9**
Principle of operation of half and full bridge inverters – Performance parameters – Voltage control of single phase inverters using various PWM techniques – various harmonic elimination techniques – forced commutated thyristor inverters- Z source inverters - power conditioners-UPS: offline UPS, online UPS.					
UNIT IV	**THREE PHASE VOLTAGE SOURCE INVERTERS AND MULTI LEVEL CONVERTERS**	**9**	**0**	**0**	**9**
180 degree and 120 degree conduction mode inverters with star and delta connected loads – voltage control of three phase inverters: single, multi pulse, sinusoidal, space vector modulation techniques – Application to drive system – **Induction heating** - Multilevel concept – diode clamped – flying capacitor – cascade type multilevel inverters -Comparison of multilevel inverters - application of multilevel inverters.					
UNIT V	**CURRENT SOURCE INVERTER**	**9**	**0**	**0**	**9**
Operation of six-step thyristor inverter – inverter operation modes – load – commutated inverters – Auto sequential curren source inverter (ASCI)– current pulsations –comparison of current source inverter and voltage source inverters – PWM techniques for current source inverters.					
Total (45L+0T)= 45 Periods					

REFERENCES:

1.	Bimbhra, P.S, "Power Electronics ", Khanna Publishers, New Delhi, 4th Edition, 2012.
2.	Rashid M.H., "Power Electronics: Circuits, Devices and Applications ", Pearson, 4th Edition, 2021.
3.	Mohan, Net al. "Power Electronics: Converters, Application and Design", Wiley India (P) Ltd, New Delhi, 3rd Editio 2010.
4.	Bimal K. Bose "Modern Power Electronics and AC Drives", Pearson Education, Second Edition, 2003.
5.	Murphy, J.M.D and Turnbull, F.G " Power Electronics Control of AC Motors ", Pergamon Press, Oxford, 1988.
6.	P.C. Sen, "Modern Power Electronics", Wheeler Publishing Co, First Edition, New Delhi, 1998.
7.	Jai P.Agrawal, "Power Electronics Systems", Pearson Education, Eight Edition, 2015
8.	www.onlinecourses.nptel.ac.in/
9.	www.class-central.com

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Get expertise in the working modes and operation of Power converters.	L2: Understanding
CO2	:	Select and design dc-dc converter topologies for a broad range of power conversion applications.	L6: Creating
CO3	:	Design single phase and three phase inverters for various applications	L6: Creating
CO4	:	Formulate and design the current source inverter.	L6: Creating
CO5	:	Identify suitable modulation techniques for Power Electronics Converters	L1: Remembering

COURSE ARTICULATION MATRIX

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	2	1	1					1	1	1		3	2	1
CO2	1	3	3	2	2		1	1	1	1	1	1	3	2
CO3	1	3	3	2	2		1	1	1	1	1	1	3	2
CO4	1	3	3	2	2		1	1	1	1	1	1	3	2
CO5	1	2	2	3	1		1	1	1	1	1	2	2	1
Avg.	1.2	2.4	2.4	2.25	1.75	0	1	1	1	1	1	1.6	2.6	1.6

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

22PEC13	ADVANCED POWER ELECTRONICS LABORATORY			SEMESTER I		
PREREQUISTIES		**CATEGORY**	**PC**	**Credit**		**2**
Electron Devices and Circuits, Power Electronics		**Hours/Week**	**L**	**T**	**P**	**TH**
			0	**0**	**4**	**4**

Course Objectives:

1.	To provide an insight on the switching behaviors of power electronic switches
2.	To make the students familiar with the digital tools used in generation of gate pulses for the power electronic switches
3.	To make the students capable of implementing analog interfacing as well as control circuits used in a closed-loop control for power electronic system
4.	To make the students acquire knowledge on mathematical modeling of power electronic circuits and implementing the same using simulation tools

LIST OF EXPERIMENTS:

1. Study of Power electronics Switches with and without Snubber (i) IGBT (ii) MOSFET
2. Simulation of 1-phase fully controlled converter with R-load, RL load, and RLE (motor) load at different firing angles.
3. Simulation of 1-phase semi-converter with R-load, RL load, and RLE (Motor) load
4. Circuit Simulation of Three-phase fully controlled converter with R, RL & RLE load.
5. Circuit Simulation of Three-phase Voltage Source Inverter in 180 and 120 degree mode of Conduction
6. Circuit simulation of Three-phase PWM inverter and study of spectrum analysis for various modulation indices.
7. Simulation of Four quadrant operation of DC Chopper.
8. Simulation of a single-phase Z-source inverter with R load.
9. Simulation of three-phase AC voltage Controller with R load.
10. Simulation of a five-level cascaded multilevel inverter with R load.
11. Simulation of Series Resonant converter with RL load.
12. Simulation of 1-phase dual converter.
13. Numerical solution of ordinary differential, partial and integral equations using MATLAB.

Total (60+0)= 60 Periods

REFERENCES:

1.	Bimbhra, P.S, "Power Electronics ", Khanna Publishers, New Delhi, 4th Edition, 2012.
2.	Rashid M.H., “Power Electronics: Circuits, Devices and Applications ", Pearson, 4th Edition, 2021.
3.	Mohan, Net al. “Power Electronics: Converters, Application and Design", Wiley India (P) Ltd, New Delhi, 3rd Editio 2010.
4.	Bimal K. Bose “Modern Power Electronics and AC Drives”, Pearson Education, Second Edition, 2003.
5.	Murphy, J.M.D and Turnbull, F.G " Power Electronics Control of AC Motors ", Pergamon Press, Oxford, 1988.
6.	P.C. Sen, “Modern Power Electronics”, Wheeler Publishing Co, First Edition, New Delhi, 1998.
7.	Jai P.Agrawal, “Power Electronics Systems”, Pearson Education, Eight Edition, 2015
8.	www.onlinecourses.nptel.ac.in/
9.	www.class-central.com

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Model power electronics converter/Inverter in software	L3: Applying
CO2	:	Simulate any power electronic converter/Inverter	L2: Understanding
CO3	:	Obtain numerical solutions of partial, differential and integral equations	L3: Applying
CO4	:	Test single phase full converter for any type of R and RL load	L4: Evaluating
CO5	:	Test single phase full converter for dc motors	L4: Evaluating

COURSE ARTICULATION MATRIX

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1		3		3	3		2	3	1		1	2	1	1
CO2	1		2		3	1	2	3		1	1	2	1	1
CO3		2	1	3	2			1			2	3	1	1
CO4				3	3		2	2	1	2		3	1	1
CO5	1		1		3	1		2	2		1	2	1	1
Avg	1	2.5	1.3	3	2.8	1	2	2.2	1.3	1.5	1.25	2.4	1	1

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

22PEC14	ADVANCED DIGITAL CONTROL LABORATORY		SEMESTER I			
PREREQUISITES		**CATEGORY**	**PC**	**Credit**		**2**
Power Electronics , Microcontroller		**Hours/Week**	**L**	**T**	**P**	**TH**
			0	**0**	**4**	**4**

Course Objectives:

1.	Implementation of DSC to various control techniques
2.	Writing coding for control techniques

LIST OF EXPERIMENTS:

1. Interfacing of LCD with DSC and displaying a message
2. Generation of Square Trigger Pulse using DSC
3. Measurement of Voltage/Current/Temperature
4. Open loop control of Buck/Boost/Buck-Boost Converter using DSC
5. Closed loop control of Buck/Boost/Buck-Boost Converter using DSC
6. Single phase square wave inverter control in open loop using DSC
7. Single phase square wave inverter control in closed loop using DSC
8. Single Phase AC-DC Converter in open loop using DSC
9. Single Phase AC-DC Converter in closed loop using DSC
10. Sine PWM based single phase inverter using DSC
11. Single phase AC Voltage controller control using DSC
12. Three Phase Inverter control using DSC

Total (60+0)= 60 Periods

REFERENCES:

1. "Microcontroller based applied digital control", D.Ibrahim, John Wiley, 2006

Course Outcomes:

Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the peripheral requirements for controlling the circuit	L2:Understanding
CO2	:	Understand and implement the configurations of various required peripherals	L3:Applying
CO3	:	Write coding to implement the devised control technique	L4:Analyzing
CO4	:	Understand and implement the measurement principles through digital techniques	L3:Applying
CO5	:	Develop algorithms for implementation of controls and implement isolation techniques for power control	L6:Creating

COURSE ARTICULATION MATRIX

COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	1	1	1	1	1	1	1	1	1	1	1	1	1	
CO2	1	1	1	1	1	1	1	1	1	1	1	1	1	
CO3	1	1	1	1	1	1	1	1	1	1	1	1	1	
CO4	1	1	1	1	1	1	1	1	1	1	1	1	1	1
CO5	1	1	1	1	1	1	1	1	1	1	1	1	1	
Avg	1	1	1	1	1	1	1	1	1	1	1	1	1	1

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

22MLC01	RESEARCH METHODOLOGY AND IPR			SEMESTER I			
PREREQUISITES		**CATEGORY**		**MLC**	**Credit**		**3**
		Hours/Week		**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

COURSE OBJECTIVES:

To develop the subject of the research, encourage the formation of higher level of trained intellectual ability, critical analysis, rigor and independence of thought, foster individual judgement and skill in the application of research theory and methods and develop skills required in writing research proposals, reports and dissertations.

UNIT I	**INTRODUCTION TO RESEARCH**	9	**0**	**0**	**9**

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of the research problem, Approaches to investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations.

UNIT II	**EFFECTIVE LITERATURE STUDIES APPROACHES, ANALYSIS**	**9**	**0**	**0**	**9**

Developing the theoretical framework of research - Developing operational statements of the problem - Criteria for evaluating research approach - Hypotheses: Parametric and non-parametric testing- Establishing the reliability and validity of findings with literature review and experiments – documentation, Plagiarism, Research ethics.

UNIT III	**EFFECTIVE TECHNICAL WRITING, HOW TO WRITE REPORT, PAPER**	**9**	**0**	**0**	**9**

Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

UNIT IV	**NATURE OF INTELLECTUAL PROPERTY**	**9**	**0**	**0**	**9**

Patents, Designs, Trade and Copyright, process of Patenting and Development: technological research, innovation, patenting, and development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

UNIT V	**PATENT RIGHTS AND IPR**	**9**	**0**	**0**	**9**

Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical indications. Administration of Patents System. New developments in IPR; IPR of Biological Systems, Computer Software etc., Traditional knowledge Case Studies, IPR and IITs.

Total(45L) = 45 Periods

REFERENCE BOOKS:

1	Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & Engineering students"
2	Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
3	Ranjit Kumar, 2 nd Edition, "Research Methodology: A Step by Step Guide for beginners"
4	Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd, 2007.
5	Mayall, "Industrial Design", McGraw Hill, 1992.
6	Niebel, "Product Design", McGraw Hill, 1974.
7	Asimov, "Introduction to Design", Prentice Hall, 1962.
8	Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in the New Technological Age", 2016.
9	T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

COURSE OUTCOMES:

On completion of the course the student will be able to			**Bloom's Taxonomy Mapped**
CO1	:	Understand research problem formulation	L2:Understanding
CO2	:	Analysis research related information	L4:Analyzing
CO3	:	Follow research ethics	L1:Remembering
CO4	:	Understand that today's world is controlled by computer, Information technology, but tomorrow's world is ruled by ideas, concepts and creativity.	L2:Understanding
CO5	:	Understand that IPR production provides an incentive to inventors for further research work and investment in R& D, which leads to creation of new and better products, and in turn brings about economic growth and social benefits.	L2:Understanding

COURSE ARTICULATION MATRIX													
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	2	2	1	3	1	-	-	-	-	-	1	2	1	-
CO2	-	3	2	2	1	1	-	3	-	1	-	2	1	-
CO3	-	-	2	-	-	1	1	1	-	3	1	-	-	-
CO4	-	-	-	2	1	-	-	-	-	2	1	-	-	2
CO5	-	-	-	-	2	1	-	1	-	-	1	-	-	3
Avg	**0.4**	**1.0**	**1.0**	**1.4**	**1.0**	**0.6**	**0.2**	**1.0**	**0.0**	**1.2**	**0.8**	**0.8**	**0.4**	**1.0**
3 / 2 / 1 -indicates strength of correction (3-High, 2-Medium, 1-Low)														

22PEC21	MODELLING AND ANALYSIS OF ELECTRICAL MACHINES					SEMESTER II
PREREQUISTIES		**CATEGORY**	**PC**	**Credit**		**3**
DC Machines , Induction Machines		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To introduce the basics of DC machines and analyze magnetic circuits
2.	To analyze the steady state and dynamic state operation of Induction machine through mathematical modeling.
3.	To analyze the various types of machines and model with different transformation techniques.
4.	To study the phase controlled, frequency controlled and vector controlled of induction motor
5.	To study the special machines and its model

UNIT I	**MODELLING OF DC MACHINES**	**9**	**0**	**0**	**9**
Equivalent circuit and electromagnetic torque - Electromechanical modelling - Field excitation: separate, shunt, series and compound excitation - commutator action. Effect of armature mmf - Analytical fundamentals: Electric circuit aspects- magnetic circuit aspects- interpoles.					
UNIT II	**DYNAMIC MODELLING OF INDUCTION MACHINES**	**9**	**0**	**0**	**9**
Equivalent circuits - steady state performance equations - Dynamic modelling of induction machines: Real time model of a two phase induction machine, Three phase to two phase transformation - Electromagnetic torque - generalized model in arbitrary reference frames - stator reference, rotor reference, synchronously rotating reference frames model.					
UNIT III	**PHASE CONTROLLED AND FREQUENCY CONTROLLED INDUCTION MOTOR**	**9**	**0**	**0**	**9**
Stator voltage control: Steady state analysis- approximate analysis- slip power recovery scheme: principle of operation - steady state analysis: Range of slip - equivalent circuit - performance characteristics - Static Scherbius drive. Constant Volts/Hz controls implementation - steady state performance - dynamic simulation. PWM voltages: Generation - machine model - computation of steady state performance.					
UNIT IV	**VECTOR CONTROLLED INDUCTION MOTOR**	**9**	**0**	**0**	**9**
Principle of vector control-direct vector control: flux and torque processor-DVC in stator reference frames with space vector modulation. Indirect vector control scheme: derivation and implementation. Flux weakening operation: principle of flux weakening operation-flux weakening in stator flux linkages-controlled schemes and rotor flux linkages-controlled schemes					
UNIT V	**MODELLING AND ANALYSIS OF SPECIAL MACHINES**	**9**	**0**	**0**	**9**
Permanent magnet synchronous machine: surface permanent magnet (square and sinusoidal back emf type) – interior permaner magnet type – Construction, operating principle and dynamic modelling – Analysis of BLDC motors					
					Total (45L+0T)= 45 Periods

References:

1.	R.Krishnan,"Electric motor drives: modelling, analysis, and control", prentice hall of India, 2010
2	P.C. Krause, "Analysis of Electric Machines and Drive Systems", Wiley International, 2013
3.	P.S.Bimbra,"generalized theory of Electric machines", khanna publishers, 5th Edition, 2017.
4.	Charles Kingley, Jr., A.E.Fitzgerald, Stephen D.Umans, "Electric Machinery",Tata McGraw Hill, 6th Edition, 2002.
5.	Miller, T.J.E., "Brushless Permanent Magnet and Reluctance Motor Drives", Clarendon Press

Course Outcomes:

Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Acquire knowledge about the DC machines and AC machines and their magnetic circuits.	L1: Remembering
CO2	:	Develop mathematical model of AC & DC machines and perform transient analysis on them.	L6: Applying
CO3	:	Understand the different types of reference frame theories and transformation relationships and Apply reference frame theory to AC machines	L2: Understanding
CO4	:	Analyze the steady state and dynamic operation of three phase induction motor and special machines using transformation theory based mathematical Modelling	L4: Analyzing
CO5	:	Select strategies to control the torque for a given application.	L4: Analyzing

COURSE ARTICULATION MATRIX

COs/ POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	2	1	1	1	3	1	3	1	1	1	1	1	1	1
CO2	2	1	3	3	1	1	3	1	1	1	1	1	3	3
CO3	2	2	2	2	3	1	3	1	1	3	1	2	2	2
CO4	2	3	2	3	3	1	2	2	1	2	1	3	2	3
CO5	2	2	3	3	3	1	2	1	1	2	2	2	3	3
Avg	2	1.8	2.2	2.4	2.6	1	2.6	1.2	1	1.8	1.2	1.8	2.2	2.4

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

22PEC22	MODERN ELECTRICAL DRIVES				SEMESTER II	
PREREQUISTIES		CATEGORY	PC	Credit		3
Electron Devices and Circuits, Power Electronics		Hours/Week	L	T	P	TH
			3	0	0	3

Course Objectives:

1.	To understand steady state operation and transient dynamics of a motor load system
2.	To study and analyze the operation of the converter / chopper fed DC drive, both qualitatively and quantitatively
3.	To analyze and design the current and speed controllers for a closed loop solid state DC motor drive.
4.	To understand the implementation of control algorithms using microcontrollers and phase locked loop.

UNIT I	DC MOTORS FUNDAMENTALS AND MECHANICAL SYSTEMS	9	0	0	9

DC motor, Types, induced emf, speed-torque relations; Speed control - Armature and field speed control; Ward Leonard control - Constant torque and constant horse power operations. Introduction to high speed drives and modern drives. Characteristics of mechanical system - dynamic equations, components of torque, types of load; Requirements of drives characteristics -multi-quadrant operation; Drive elements, types of motor duty and selection of motor rating.

UNIT II	CONVERTER CONTROL	9	0	0	9

Principle of phase control - Fundamental relations; Analysis of series and separately excited DC motor with single-phase and three-phase converters - waveforms, performance characteristics. Continuous and discontinuous armature current operations; Current ripple and its effect on performance; Operation with freewheeling diode; Implementation of braking schemes; Drive employing dual converter.

UNIT III	INTRODUCTION TO INDUCTION MOTORS	9	0	0	9

Steady state performance equations – Rotating magnetic field – torque production, Equivalent circuit– Variable voltage, constant frequency operation –Variable frequency operation, constant Volt/Hz operation. Drive operating regions, variable stator current operation, different braking methods.

UNIT IV	FIELD ORIENTED CONTROL	9	0	0	9

Field oriented control of Induction machines – Theory – DC drive analogy – Direct and Indirect methods – Flux vector estimation - Direct torque control of Induction Machines – Torque expression with stator and rotor fluxes, DTC control strategy.

UNIT V	SYNCHRONOUS MOTOR DRIVES	9	0	0	9

Wound field cylindrical rotor motor – Equivalent circuits – performance equations of operation from a voltage source – startin and braking, self control – Load commutated Synchronous motor drives - Brush and Brushless excitation - Sensor-les operation..

Total (45L+0T)= 45 Periods

REFERENCES:

1.	Dubey,G.K. "Power Semiconductor Controlled Drives ", PH International, New Jersey, 1989.
2.	Bimal K Bose, “Modern Power Electronics and AC Drives”, Pearson Education Asia 2004.
3.	GobalK.Dubey, “Fundamentals of Electrical Drives”, Narosal Publishing House, New Delhi,Second Edition ,2009.
4.	Sen, P.C. "Thyristor D.C Drives ", John Wiley & Sons, New York, 1981.
5.	R.Krishnan, “Electric Motor Drives – Modeling, Analysis and Control”, Prentice-Hall of India Pvt. Ltd., New Delhi, 2003.
6.	Subharamanyam V. "Electric Drives-Concepts and Applications ", TMH Publi., 1994.
7.	W.Leonhard, “Control of Electrical Drives”, Narosa Publishing House, 1992.
8.	Murphy J.M.D and Turnbull, “Thyristor Control of AC Motors”, Pergamon Press, Oxford, 1988.
9	www.onlinecourses.nptel.ac.in/
10.	www.class-central.com

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Select suitable drives for industries.	L4: Analyzing
CO2	:	Analyse various characteristics of electrical drives with single and three phase converters.	L4: Analyzing
CO3	:	Suggest suitable speed control method for the electrical drives	L2: Understanding
CO4	:	Operate power electronics converters in continuous/discontinuous mode	L2: Understanding
CO5	:	Use closed loop control schemes for electrical motor drives.	L3: Applying

COURSE ARTICULATION MATRIX

COs/ POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	1				2	1	2		2	1	2	3	2	1
CO2	1	3	3	2	2	1	2	2	1		1	2	1	1
CO3	1			2	2	1		2	1		1	3	2	1
CO4	1		2	2	2		2	2			1	2	2	1
CO5	1	2	3	2	3		2	2		1	1	3	2	1
Avg	1	2.5	2.6	2	2.2	1	2	2	1.3	1	1.2	2.6	1.8	1

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

22PEC23	POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEM LABORATORY					SEMESTER II
PREREQUISTIES		**CATEGORY**	**PC**	**Credit**		**2**
Electron Devices and Circuits, Power Electronics		**Hours/Week**	**L**	**T**	**P**	**TH**
			0	**0**	**4**	**4**

Course Objectives:

1.	To provide an insight on the switching behaviors of power electronic switches
2.	To make the students familiar with the digital tools used in generation of gate pulses for the power electronic switches
3.	To make the students capable of implementing analog interfacing as well as control circuits used in a closed-loop control for power electronic system
4.	To make the students acquire knowledge on renewable energy conversion system

LIST OF EXPERIMENTS:

1. Single phase ac voltage controller using SCR and TRIAC
2. Three phase half and fully controlled bridge converter
3. Single phase series inverter
4. IGBT based three phase PWM Inverter
5. MOSFET based buck boost converter
6. DC-DC forward converter
7. DC-DC flyback converter
8. Single phase dual converter
9. DC series resonant converter
10. Solar PV energy conversion system
11. wind energy conversion system
12. Simulation of Fuel cell energy conversion system
13. Simulation of grid tied inverter for solar PV energy conversion system
14. Simulation of hybrid (PV-Diesel, Wind-Diesel, Hydro-PV, Biomass-PV) energy conversion system

Total (60+0)= 60 Periods

REFERENCES:

1.	Bimbhra, P.S, "Power Electronics ", Khanna Publishers, New Delhi, 4thEdition, 2012.
2.	Rashid M.H., “Power Electronics: Circuits, Devices and Applications ", Pearson, 4th Edition, 2021.
3.	GobalK.Dubey, “Fundamentals of Electrical Drives”, Narosal Publishing House, New Delhi,Second Edition ,2009.
4.	Sen, P.C. "Thyristor D.C Drives ", John Wiley & Sons, New York, 1981.
5.	R.Krishnan, “Electric Motor Drives – Modeling, Analysis and Control”, Prentice-Hall of India Pvt. Ltd., New Delhi, 2003.
6.	Subharamanyam V. "Electric Drives-Concepts and Applications ", TMH Publi., 1994.
7.	W.Leonhard, “Control of Electrical Drives”, Narosa Publishing House, 1992.
8.	Murphy J.M.D and Turnbull, “Thyristor Control of AC Motors”, Pergamon Press, Oxford, 1988.
9.	Dubey,G.K. "Power Semiconductor Controlled Drives ", PH International, New Jersey, 1989.
10.	Bimal K Bose, “Modern Power Electronics and AC Drives”, Pearson Education Asia 2004.
11.	Chetan Singh Solanki : Solar photovoltaics: Fundamental Technology and Application, Second Edition, PHI, 2012
12	www.onlinecourses.nptel.ac.in/
13	www.class-central.com

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Identification of suitable analog and digital controller for the converter design.	L1: Remembering
CO2	:	Test the power electronics converters/Inverters	L5:Evaluating
CO3	:	Know the significance of gate driver, sensing and protection circuits in power converters.	L2:Understanding
CO4	:	Design the power converters such as AC-DC, DC-DC, and AC-AC converters for Solar energy systems	L6:Creating
CO5	:	Design the power converters such as AC-DC, DC-DC, and AC-AC converters for Wind energy systems	L6:Creating

COURSE ARTICULATION MATRIX

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	2		3	3	3		2	3	2		2	3	2	1
CO2	2	3	3		3	1	2	3	1	1	1	3	2	1
CO3	2	3			2	1	1	1			1	3	1	1
CO4			3	3	3	1	2	3	1		1	2	1	1
CO5	2	3	3		3		2	3		1	1	2	1	1
Avg	2	3	3	3	2.8	1	1.8	2.6	1.3	1	1.2	2.6	1.4	1

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

22PEC24	ADVANCED ELECTRICAL DRIVES LABORATORY			SEMESTER II			
PREREQUISITES		**CATEGORY**		**PC**	**Credit**		**2**
AC and DC Drives		**Hours/Week**		**L**	**T**	**P**	**TH**
				0	**0**	**4**	**4**

Course Objectives:

1.	To analyze the operation of DC and AC motor drives
2.	To study the performance of PMSM, BLDC and SRM drives
3.	To gain knowledge on closed loop control of PMSM, BLDC and SRM drives.

LIST OF EXPERIMENTS:

1. Four quadrant chopper fed DC motor drive
2. V/f control of three phase induction motor with voltage source inverter
3. DSP based speed control of SRM motor
4. DTC control of Induction motor drive
5. Self-controlled synchronous motor drive
6. Closed loop control of PMSM motor
7. Simulation study of four quadrant operation of DC drives using dual converter circuit
8. Simulation study of Field oriented control induction motor drive
9. Simulation study of CSI fed three phase induction motor drive
10. Simulation study of closed loop control of BLDC motor drive

Total (60+0)= 60 Periods

REFERENCES:

1. "Advanced and Intelligent Control in Power Electronics and Drives", R.Kennel, Springer, 2014.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Design closed loop control for PMSM and SRM drives.	L3:Applying
CO2	:	Analyze the operation of VSI and CSI fed induction motor drives	L4:Analyzing
CO3	:	Select suitable inverter configuration and control for three phase induction motor drives.	L6:Creating
CO4	:	Analyze the operation of synchronous motor drives.	L4:Analyzing
CO5	:	Use digital control for special motor drives.	L3:Applying

COURSE ARTICULATION MATRIX

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	2		3	2		1		2		1		1	1	
CO2	1	3						1				1	1	
CO3	3		1					1			2	1	1	
CO4	1	3						2				1	1	1
CO5	2			3	1			1				1	1	1
Avg	1.8	3	2	2.5	1	1	0	1.4	0	1	2	1	1	1

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

2PEE11	ADVANCED MICROCONTROLLER BASED SYSTEM DESIGN				SEMESTER I	
PREREQUISTIES		**CATEGORY**	**PE**	**Credit**		**3**
Microprocessors and Microcontroller		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1. To implement digital control for power electronic applications
2. To learn various DSP peripherals for proper implementations to power applications

UNIT I	**INTRODUCTION TO DSPIC 30F DIGITAL SIGNAL CONTROLLER**	**9**	**0**	**0**	**9**
dsPIC 30F CPU Core – Programmers Model – CPU Registers – DSP Engine – Memory Organization – Data – Program – Flash and EEPROM Programming.					
UNIT II	**SYSTEM CONFIGURATION**	**9**	**0**	**0**	**9**
Oscillator Configuration – Power saving Modes - Various Resets – Device Configuration – Low Voltage Detect - I/O Ports					
UNIT III	**CONTROL PERIPHERALS**	**9**	**0**	**0**	**9**
Study, Configuration and control - Interrupt Structure – Timers – Capture and Compare – AD Converter–Introduction to IDE for dsPIC and Project development with simple C programming.					
UNIT IV	**MOTOR CONTROL PERIPHERALS**	**9**	**0**	**0**	**9**
Motor Control PWM – Different PWM modes – Dead Time – Output and Polarity Control – PWM Fault Pins – Quadrature Encoder Interface					
UNIT V	**APPLICATIONS**	**9**	**0**	**0**	**9**
Closed loop Control of Single and three Phase VSI, Sensored and Sensorless BLDC Motor Control – AC Induction Motor Control – Vector Control of AC Induction Motor - Servo Control of a DC-Brush Motor - Four Channel Digital Voltmeter with Display					
					Total (45L+0T)= 45 Periods

References:

1. dsPIC30F Family Reference Manual, Datasheets.
2. Creed Huddleston, “Intelligent Sensor Design using Microchip dsPIC ", Newnes, 2007.
3. Zoran Milivojević, DjordjeŠaponjić, “Programming dsPIC (Digital SignalControllers) in C”, MicroElectronika

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Understand various DSP peripherals	L2:Understanding
CO2	:	Understand the configurations of peripherals for appropriate power applications	L1:Remembering
CO3	:	Write C coding for implementing controls using peripherals	L4:Analyzing
CO4	:	Implement interfacing techniques with DSP for control applications	L3:Applying
CO5	:	Understand and implement the control techniques for power electronic applications	L5:Evaluating

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
CO2	1	2	2	1	1	1	1	1	1	1	1	1	1	1
CO3	1	2	2	1	1	1	1	1	1	1	1	1	1	1
CO4	1	2	2	1	1	1	1	1	1	1	1	2	2	1
CO5	1	2	2	1	1	1	1	1	1	1	1	2	2	1
Avg	1	1.80	1.80	1	1	1	2.20	1	1	0.00	1	1.40	1.40	1

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

22PEE12	APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERING		SEMESTER I			
PREREQUISTIES		**CATEGORY**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To familiarize the students in the field of variational problems.
2.	To acquire the techniques in solving simultaneous equations.
3.	To impart the knowledge in solving differential equations.
4.	To procure the solutions of linear programming using Graphical and Simplex methods.
5.	To understand the overall approach of dynamic programming.

UNIT I	**CALCULUS OF VARIATIONS**	**9**	**0**	**0**	**9**
Concept of Variation and its properties – Euler's equation – Functional dependent on first and higher order derivatives – Functional dependent on functions of several independent variables– Some applications – Direct methods: Ritz and Kantorovich methods.					
UNIT II	**SOLUTION OF EQUATIONS**	**9**	**0**	**0**	**9**
Newton Raphson method, Curve fitting (Least square), Direct method: Gaussian Elimination, Gauss–Jordan and Factorisation methods – Iterative method: Gauss-Jacobi, Gauss - Seidel Methods.					
UNIT III	**NUMERICAL SOLUTION OF BOUNDARY VALUE PROBLEMS**	**9**	**0**	**0**	**9**
Numerical solution of ordinary Differential Equations-Euler' method-Euler's modified method – Taylor's method and Runge – Kutta method for simultaneous equations and 2nd order equations – Multistep methods – Milne's and Adam's methods.					
UNIT IV	**LINEAR PROGRAMMING**	**9**	**0**	**0**	**9**
Basic concepts – Graphical and Simplex methods – Transportation problem – Assignment problem					
UNIT V	**DYNAMIC PROGRAMMING**	**9**	**0**	**0**	**9**
Elements of the dynamic programming model – optimality principle –Examples of dynamic programming models and their solutions.					
Total (45L+0P) = 45 Periods					

References:

1.	Grewal, B.S., Higher Engineering Mathematics, 43rd edition, Khanna Publishers, New Delhi 2014.
2.	Gupta, A.S., Calculus of Variations with Applications, Prentice Hall of India Pvt. Ltd., New Delhi 2004.
3.	Gerald.C.F and Wheatley.P.O. "Applied Numerical analysis", Pearson Education, Asia, 7th edition, New Delhi, 2006
4.	Taha, H.A., "Operations research – An Introduction", 9th Edition, Pearson Education Edition, Asia, New Delhi (2014).
5.	Kanti Swarup, P.K.Gupta & Man Mohan" Operation Research", 17th Edition, Reprint 2014. JBA Publishers. New Delhi.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the concept of variational problems and its techniques.	L2:Understanding
CO2	:	Solve the linear equations	L6:Creating
CO3	:	determine the numerical solutions of differential equations	L3:Applying
CO4	:	Solve the Transportation and Routing problems using Optimization Techniques	L6:Creating
CO5	:	Gain the knowledge and concept of Dynamic Problems and techniques to solve	L3:Rembaberering

COURSE ARTICULATION MATRIX														
COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1			3	1	1	1	1	1	1	1	1		1	1
CO2			3	1	1	2	2	1	1	1	1		1	1
CO3			3	1	1	2	1	1	2	1	3		2	1
CO4			1	1	1	1	2	1	1	1	1		1	1
CO5			1	1	1	2	1	1	1	1	3		1	1
Avg			2.2	1	1	1.6	1.4	1	1.2	1	1.8		1.2	1
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)														

22PEE13	SYSTEM THEORY					SEMESTER I
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Power Electronics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To educate on modelling and representing systems in state variable form
2.	To educate on solving linear and non-linear state equations
3.	To illustrate the role of controllability and observability
4.	To gain knowledge on stability analysis of systems using Lyapunov's theory
5.	To impart knowledge on modal concepts and design of state and output feedback controllers and estimators

UNIT I	**STATE VARIABLE REPRESENTATION**	**9**	**0**	**0**	**9**
Introduction - Concept of State - State equations for Dynamic Systems - Time invariance and linearity - Nonuniqueness of state model - State Diagrams - Physical System and State Assignment: Linear continuous-time models – Inverted pendulum.					
UNIT II	**SOLUTION OF STATE EQUATIONS**	**9**	**0**	**0**	**9**
Existence and uniqueness of solutions to Continuous-time state equations - Solution of Nonlinear and Linear Time-Varying State equations - Evaluation of matrix exponential - System modes - Role of Eigenvalues and Eigenvectors.					
UNIT III	**CONTROLLABILITY AND OBSERVABILITY**	**9**	**0**	**0**	**9**
General concepts: Controllability and Observability - Stabilizability and Detectability - Tests for Continuous time Systems: Time-varying and Time-invariant cases - Output Controllability – Reducibility - System Realizations: Phase-variable canonical forms – Jordan canonical form.					
UNIT IV	**STABILITY**	**9**	**0**	**0**	**9**
Introduction - Equilibrium Points - Stability in the sense of Lyapunov - BIBO Stability -Stability of LTI Systems - Equilibrium Stability of Nonlinear Continuous-Time Autonomous Systems - The Direct Method of Lyapunov and the Linear Continuous-Time Autonomous Systems - Finding Lyapunov Functions for Nonlinear Continuous-Time Autonomous Systems - Krasovski and Variable-Gradiant Methods.					
UNIT V	**POLE PLACEMENT**	**9**	**0**	**0**	**9**
Introduction - Controllable and Observable Companion Forms: SISO and MIMO Systems - The Effect of State Feedback on Controllability and Observability - Pole Placement by State Feedback for both SISO and MIMO Systems - Full Order and Reduced Order Observers.					
Total (45L+0T)= 45 Periods					

References:

1.	Gopal, M., "Modern Control System Theory", New Age International, 2005.
2.	Gopal, M., "Digital Control and State Variable Methods", Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2003.
3.	Bubnicki, Z., "Modern Control Theory", Springer Publishers, 2005.
4.	Ogatta, K., "Modern Control Engineering", Prentice Hall of India, 2002.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Discuss the concept of state variable representation of systems.	L2: Understanding
CO2	:	Solve linear and non-linear state equations.	L3: Applying
CO3	:	Analyze the concepts of controllability and observability.	L4: Analyzing
CO4	:	Develop the stability analysis of nonlinear systems.	L4: Analyzing
CO5	:	Explain the concepts of Pole placement and State feedback.	L2: Understanding

COURSE ARTICULATION MATRIX														
COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	1	3	1	1	2	1	3	1	1	1	1	3	3	1
CO2	1	1	3	3	1	2	3	1	1	2	1	1	3	2
CO3	1	1	2	2	2	2	1	1	2	3	1	3	2	2
CO4	2	3	2	3	3	1	2	2	1	2	2	2	3	1
CO5	2	2	3	2	3	1	2	3	1	2	2	2	2	2
Avg	1.40	2.00	2.20	2.20	2.20	1.40	2.20	1.60	1.20	2.00	1.40	2.20	2.60	1.60
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)														

22PEE14	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING					SEMESTER V
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Mathematics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To provide a strong foundation of fundamental concepts in Artificial Intelligence.
2.	To enable the student to apply these techniques in applications which involve perception, reasoning and learning.
3.	To enable Problem-solving through various searching techniques.
4.	To simulate numerous innate human skills such as automatic programming, case – based reasoning, neural networks, Fuzzy Logic, decision-making, expert systems, pattern recognition and speech recognition, etc.
5.	To apply AI techniques primarily for machine learning, vision, and robotics.

UNIT I	**INTRODUCTION TO Al AND PRODUCTION SYSTEMS**	**9**	**0**	**0**	**9**
Introduction to AI-Problem formulation, Problem Definition -Production systems, Control strategies, Search strategies. Problem characteristics, Production system characteristics -Specialized production system- Problem solving methods - Problem graphs, Matching, Indexing and Heuristic functions -Hill Climbing-Depth first and Breath first, Constraints satisfaction - Related algorithms, Measure of performance and analysis of search algorithms.					
UNIT II	**REPRESENTATION OF KNOWLEDGE**	**9**	**0**	**0**	**9**
Game playing - Knowledge representation, Knowledge representation using Predicate logic, Introduction to predicate calculus, Resolution, Use of predicate calculus, Knowledge representation using other logic-Structured representation of knowledge.					
UNIT III	**KNOWLEDGE INFERENCE**	**9**	**0**	**0**	**9**
Knowledge representation -Production based system, Frame based system. Inference - Backward chaining, Forward chaining, Rule value approach, Fuzzy reasoning - Certainty factors, Bayesian Theory-Bayesian Network-Dempster - Shafer theory.					
UNIT IV	**PLANNING AND MACHINE LEARNING**	**9**	**0**	**0**	**9**
Basic plan generation systems - Strips -Advanced plan generation systems – K strips -Strategic explanations -Why, Why not and how explanations. Learning- Machine learning, adaptive Learning.					
UNIT V	**EXPERT SYSTEMS**	**9**	**0**	**0**	**9**
Expert systems - Architecture of expert systems, Roles of expert systems - Knowledge Acquisition –Meta knowledge Heuristics. Typical expert systems - MYCIN, DART, XOON, Expert systems shells.					
Total (45L+0T)= 45 Periods					

References:

1.	David L. Poole, Alan K. Mackworth, "Artificial Intelligence: Foundations of Computational Agents", Cambridge University Press, 2010.
2.	Dan W.Patterson, "Introduction to Artificial Intelligence and Expert Systems", PHI, 2006.
3.	Nils J. Nilsson, "Artificial Intelligence: A new Synthesis", Harcourt Asia Pvt. Ltd., 2000.
4.	Stuart Russell, Peter Norvig, "Artificial Intelligence: A Modern Approach", Third Edition, Pearson Education / Prentice Hall of India, 2010.
5.	Elaine Rich and Kevin Knight, "Artificial Intelligence", Third Edition, Tata McGraw-Hill, 2010.
6.	Ethem Alpaydin, "Introduction to Machine Learning (Adaptive Computation and Machine Learning series)", The MIT Press; Second edition, 2009.
7.	Patrick H. Winston. "Artificial Intelligence", Third edition, Pearson Edition, 2006.
8.	Bratko I, "Prolog Programming for Artificial Intelligence", Addison-Wesley Educational Publishers Inc; Fourth Edition, 2011.
9.	www.onlinecourses.nptel.ac.in

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Provide a basic exposition to the goals and methods of Artificial Intelligence.	L1 Remembering
CO2	:	Study the design of intelligent computational agents.	L2 Understanding
CO3	:	Acquire knowledge through learning can be used both for problem solving and for reasoning planning, natural language understanding, computer vision, automatic programming and machine learning.	L5 Evaluating
CO4	:	Apply innate human skills such as automatic programming, case – based reasoning, neural networks, Fuzzy Logic, decision-making, expert systems, natural language processing, pattern recognition and speech recognition, etc.	L4 Analyzing
CO5	:	Enhance their knowledge in their Research works in future.	L3 Applying
CO6	:	Build new solutions in business in future.	L6 Creating

COURSE ARTICULATION MATRIX

COs/ Pos	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO1 1**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	2	2	2	1	1	1	2	1	1	2	1	2	1	2
CO2	3	1	1	2	2	1	1	1	2	2	1	1	1	1
CO3	1	1	1	2	1	1	2	2	2	2	2	2	1	2
CO4	1	2	2	3	3	1	1	2	1	1	1	1	1	1
CO5	1	1	1	1	1	2	2	1	2	1	1	2	1	2
CO6	1	1	1	2	1	1	1	2	3	3	3	1	1	1
Avg	1.5	1.3	1.3	1.8	1.5	1..2	1.5	1.5	1.8	1.8	1.5	1.5	1	1.5

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

22PEE15	DIGITAL CONTROL SYSTEM					SEMESTER I
PREREQUISTIES		**CATEGORY**	**PE**	**Credit**		**3**
Control Systems and Digital Signal Processing		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To understand the digital signal processing.
2.	To study the design of sampled data control systems in state space.
3.	To impart knowledge on digital control algorithms and stability study.

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Review of frequency and time response analysis and specifications of continuous time systems - need for controllers - continuous time compensations - continues time PI, PD, PID controllers, Realization of basic compensators: Lag , Lead and Lag-Lead compensation schemes - problems.

UNIT II	**SIGNAL PROCESSING IN DIGITAL CONTROL**	**9**	**0**	**0**	**9**

Need for digital control – Configuration of basic digital control scheme – Principles of signal conversion – Basic discrete-time signals – Time domain and frequency domain models for discrete-time systems - Aliasing – Reconstruction of analog signals – Practical aspects of the choice of sampling rate – Discretization based on bilinear transformation.

UNIT III	**MODELING AND ANALYSIS OF SAMPLED DATA CONTROL SYSTEM**	**9**	**0**	**0**	**9**

Differential equation description – Z-transform method of description– Z-transform analysis of sampled data control systems –Jury's stability test – Routh stability criterion on the r-plane – State variable concepts: First companion – Second companion – Jordan canonical models – Discrete state variable models – state description of sampled continuous time plants, Elementary principles.

UNIT IV	**DESIGN OF DIGITAL CONTROL ALGORITHMS**	**9**	**0**	**0**	**9**

Introduction – z-plane specifications of control system design –Digital lead , lag and lag-lead compensator design using frequency response plots - Digital lead lag compensator design using Root locus plots – z-plane synthesis – Digital controllers for deadbeat performance – Examples: Digital Controller Design for Buck Converter.

UNIT V	**PRACTICAL ASPECTS OF DIGITAL CONTROL ALGORITHMS**	**9**	**0**	**0**	**9**

Development and implementation of digital PID control algorithms – Tunable PID controllers - Digital temperature control system: Control algorithm – Digital position control system: Digital measurement of shaft position/speed, control algorithm – Stepping motors and their controls: Torque-speed curves, Interfacing of stepper motors to microprocessors, Design of fuzzy logic controllers, Fuzzy control of water heater.

Total (45L+0T)= 45 Periods

References:

1.	M. Gopal, "Digital Control and Static Variable Methods", Tata McGraw Hill, New Delhi, 2012, Fourth Edition.
2.	I.J. Nagrath & M. Gopal, "Control Systems Engineering", New Age International Publishers, New Delhi, 2017, Sixth Edition.
3.	B.C. Kuo, Digital Control Systems, Oxford University Press, Second Edition, 2007.
4.	K. Ogata, Modern Control Engineering, Pearson Education, 2002.
5.	Kenneth J. Ayala, "The 8051 Microcontroller- Architecture, Programming and Applications", Penram International, 2nd Edition, 1996.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Get knowledge about digital control scheme.	L2:Understanding
CO2	:	Get knowledge about sampling techniques.	L1:Remembering
CO3	:	Design the various digital control algorithms.	L4:Analyzing
CO4	:	Design the various types of digital controllers and compensators.	L3:Applying
CO5	:	Get knowledge about applications of digital control.	L5:Evaluating

COURSE ARTICULATION MATRIX														
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	1	1	1	1	1	1	1	1	1	2	1	1	1	1
CO2	1	1	1	1	1	1	1	1	1	2	1	1	1	1
CO3	1	1	2	2	3	1	3	2	1	2	1	1	1	1
CO4	1	3	3	3	3	1	3	3	1	2	1	2	2	1
CO5	2	2	3	3	3	1	2	3	1	2	1	2	2	1
Avg	1.2	1.60	2.0	2.0	2.2	1	2.0	2.0	1	2.0	1	1.40	1.40	1
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)														

22PEE21	ADVANCED POWER ELECTRONIC CIRCUITS			SEMESTER I			
PREREQUISTIES		**CATEGORY**		**PE**	**Credit**		**3**
NIL		**Hours/Week**		**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

1.	To provide exposure of advanced power electronic converters to be utilized by the industries and utilities

UNIT I	**MULTIPULSE CONVERTERS**	**9**	**0**	**0**	**9**
Concept of multi-pulse converters, Configurations for twelve pulse, eighteen pulse and twenty four pulse rectifiers, operation and waveform analysis, phase shifting transformer configurations for multi-pulse converters, Applications					
UNIT II	**PULSE-WIDTH-MODULATED DC-DC CONVERTERS**	**9**	**0**	**0**	**9**
Forward converter, Half bridge and full-bridge converters, SEPIC Converter; Interleaved boost converter, transformer-isolated converter topologies, continuous and discontinuous conduction modes of operation, current ripple analysis of DC-DC converters					
UNIT III	**HIGH POWER CONVERTERS**	**9**	**0**	**0**	**9**
Diode Clamped Type and Flying Capacitor Type Multi-Level Inverters and suitable modulation strategies - Multi-level inverters of Cascade Type, Series Inverters. Analysis of Series Inverters. Modified Series Inverter. Three Phase Series Inverter					
UNIT IV	**BIDIRECTIONAL CONVERTERS**	**9**	**0**	**0**	**9**
Single Phase and three Phase bidirectional converters in rectifier mode, control of DC voltage - control of Input Current. Hysteresis control in Single Phase and three Phase inverter mode - Frequency control in hysteresis, Constant switching frequency control methods.					
UNIT V	**RESONANT CONVERTERS**	**9**	**0**	**0**	**9**
Resonant switch converters, Zero voltage switching clamped voltage converters, Resonant DC link inverters High frequency link integral half cycle converters, Phase modulated resonant converters, Dual active bridge converters, High gain converters.					
Total (45L+0T)= 45 Periods					

References:

1.	Bin Wu, “High Power Converters and AC Drives”, John Willey & sons, Inc., 2017.
2.	N. Mohan, Power Electronics: A First Course, John Wiley & Sons, 2014.
3.	B. K Bose “Modern Power Electronics and AC Drives” Pearson Education, 2022.
4.	https://archive.nptel.ac.in/courses/108/107/108107128

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Level**
CO1	:	Explain the operating modes of new DC-DC voltage regulators	L2-Understanding
CO2	:	Select appropriate phase shifting converter for a multi-pulse converter operation	L4-Analyzing
CO3	:	Identify an inverter configuration for high power AC applications	L1-Remembering
CO4	:	Use of appropriate control method for bidirectional converters	L3-Applying
CO5	:	Analyze resonant converters with optimal component selection	L4-Analyzeing

COURSE ARTICULATION MATRIX

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	2	1	2			1	2	2	2		1	2	2	1
CO2	1				2	1		1	1	3		2	1	
CO3	2	1	2	2	1		2	1		2	2	1	2	1
CO4	3		3	1	2				1	1	2	2	2	1
CO5	1	3		1		1	1	1	2		1	2	1	
Avg	1.80	1.67	2.33	1.33	1.67	1.00	1.67	1.25	1.50	2.00	1.50	1.80	1.60	1.00

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

22PEE22	APPLIED DIGITAL CONTROL FOR POWER ELECTRONICS		SEMESTER I			
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Control Systems		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:				
To understand the basic concepts of discrete time systems, analysis, controller design and realization.				
UNIT I SAMPLED DATA SYSTEMS AND Z TRANSFORMS	**9**	**0**	**0**	**9**
Sampling Process – Z Transform of various signals - The z-Transform Function Expressed as a Laplace Transform - Properties of z-Transforms - Inverse z-Transforms - Pulse Transfer Function and Manipulation of Block Diagrams				
UNIT II SYSTEM TIME RESPONSE CHARACTERISTICS	**9**	**0**	**0**	**9**
Time Response Comparison - Time Domain Specifications - Mapping the s-Plane into the z-Plane - Damping Ratio and Undamped Natural Frequency in the z-Plane - Damping Ratio - Undamped Natural Frequency - Damping Ratio and Undamped Natural Frequency Using Formulae				
UNIT III SYSTEM STABILITY	**9**	**0**	**0**	**9**
Factorizing the Characteristic Equation - Jury's Stability Test - Routh–Hurwitz Criterion - Root Locus - Nyquist Criterion - Bode Diagrams				
UNIT IV DISCRETE CONTROLLER DESIGN	**9**	**0**	**0**	**9**
Digital Controllers - Dead-Beat Controller - Dahlin Controller - Pole-Placement Control – Analytical - Pole-Placement Control – Graphical - PID Controller - Saturation and Integral Wind-Up - Derivative Kick - PID Tuning – PR Controller – Analysis and Design				
UNIT V CONTROLLER REALIZATION	**9**	**0**	**0**	**9**
Direct Structure - Direct Canonical Structure - Direct Noncanonical Structure - Cascade Realization - Parallel Realization - PID Controller Implementations - Microcontroller Implementations - Implementing Second-Order Modules - Implementing First-Order Modules - Implementing Higher-Order Modules - Choice of Sampling Interval				
Total (45L+0T) = 45 Periods				

References:

1.	Dogan Ibrahim "Microcontroller Based Applied Digital Control", John Wiley & Sons 2006.
2.	Dong-Jin Lim, "Control System Engineering: Design and Implementation using ARM Cortex-M Microcontroller", Edition 1, Copyright © 2021 Dong-Jin Lim
3.	Gene F. Frankin, David Powel, and Abbas Emami-Naeini. "Feedback Control of Dynamic Systems"' 7th ed. Pearson, 2014.
4.	Sami Fadali and Antonio Visioli , "Digital Control Engineering Analysis and Design", 2^{nd} Edition, Academic Press.

Course Outcomes:

Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the basic concepts of sampled data system and significance of transforms.	L2:Understanding
CO2	:	Appreciate the importance of various factor involved in time response of a system	L1:Remembering
CO3	:	Analyze the stability of a system from digital point of view	L4:Analyzing
CO4	:	Able to choose and design an appropriate controller of requirements	L5:Evaluating
CO5	:	Able to realize the controller designed in the suitable form for implementation in microcontroller.	L6:Creating

COURSE ARTICULATION MATRIX													
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	1	2	3	3	1						1	2	1	
CO2	2	2	2	2	1							2	1	
CO3	1	2	3	2	1						1	3	2	
CO4	3	3	2	3	3	1		3				2	3	2
CO5	3	3	2	3	2	1	2	3			2	3	2	
Avg	2	2.4	2.4	2.6	1.6	1	2	3	0	0	1.3	2.4	1.8	2
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)														

22PEE23	MODERN RECTIFIERS AND RESONANT CONVERTERS			SEMESTER I		
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Analysis of Power Converters		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

To gain knowledge about 1-phase & full wave converter with continuous and discontinuous mode of conduction and reduction of harmonics & minimization of THD, realization of non-ideal rectifiers with control of current and hysteresis, the average model for buck, boost and buck-boost converter and design of controllers

UNIT I	**POWER SYSTEM HARMONICS & LINE COMMUTATED RECTIFIERS**	**9**	**0**	**0**	**9**

Average power-RMS value of a waveform-Power factor-AC line current harmonic standards IEC 1000-IEEE 519- The Single phase full wave rectifier-Continuous Conduction Mode-Discontinuous Conduction Mode-Behaviour when C is large, Minimizing THD when C is small-Three phase rectifiers-Continuous Conduction Mode- Discontinuous Conduction Mode-Harmonic trap filters.

UNIT II	**PULSE WIDTH MODULATED RECTIFIERS**	**9**	**0**	**0**	**9**

Properties of Ideal rectifiers-Realization of non-ideal rectifier-Control of current waveform-Average current control-Current programmed Control- Hysteresis control- Nonlinear carrier control.

Unit III	**SINGLE PHASE CONVERTER SYSTEM**	**9**	**0**	**0**	**9**

Single phase converter system incorporating ideal rectifiers- Modeling losses and efficiency in CCM high quality rectifiers-Boost rectifier Example - expression for controller duty cycle-expression for DC load current-solution for converter Efficiency.

Unit IV	**RESONANT CONVERTERS**	**9**	**0**	**0**	**9**

Review on Parallel and Series Resonant Switches-Soft Switching-Zero Current Switching - Zero Voltage Switching - Classification of Quasi resonant switches-Zero Current Switching of Quasi Resonant Buck converter -Zero Current Switching of Quasi Resonant Boost converter - Zero Voltage Switching of Quasi Resonant Buck converter - Zero Voltage Switching of Quasi Resonant Boost converter - Steady State analysis.

Unit V	**DYNAMIC ANLYSIS OF POWER CONVERTERS**	**9**	**0**	**0**	**9**

Review of linear system analysis-State Space Averaging-Basic State Space Average Model-State Space Averaged model for an ideal Buck Converter, ideal Boost Converter, ideal Buck Boost Converter, for an ideal Cuk Converter -Pulse Width Modulation-Voltage Mode PWM Scheme-Current Mode PWM Scheme - Design of Controllers - PI Controller, Variable Structure Controller, Optimal Controller for the source current shaping of PWM rectifiers.

Total (45+0) =45 Periods

References

1.	Robert W. Erickson &Dragon Maksimovic “Fundamentals of Power Electronics” 2nd Edition, 2001 Springer science and Business media.
2.	Mohammed H.Rashid, “Power Electronics”, Pearson Education- Third Edition –first Indian reprint – 2004.
3.	Mohan .N, Undeland& Robbins “Power Electronics – Converters, Application & Design”, John Wiley & Sons, Inc, 2nd Edition, Newyork, 2001.
4.	William Shepherd and Li zhang, Marceld Ekkerin.C “Power Converters Circuits”.
5.	Simon Ang and Alejandro Oliva “Power- Switching Converters”, Taylor & Francis Group.
6.	Philip T Krein, “ Elements of Power Electronics”, Oxford University Press,1998
7.	John G. Kassakian, Martin F. Schlecht, George C. Verghese, “Principles of Power Electronics”, Pearson, India, New Delhi, 2010.

Course Outcomes:			
Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	To understand the standards for supply current harmonics and its significance.	L2:Understanding
CO2	:	To design PWM rectifiers	L3:Applying
CO3	:	To analyze and design the single phase converter system	L4:Analyzing
CO4	:	To analyze and design the resonant converters.	L4:Analyzing
CO5	:	To understand the dynamics of power converters	L2:Understanding

COURSE ARTICULATION MATRIX

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	2	2	3	2	3	1	3	3	1	1	1	2	2	1
CO2	2	2	3	2	3	1	3	3	1	1	1	2	3	1
CO3	3	2	2	2	3	1	3	3	1	1	1	2	3	1
CO4	2	2	2	2	3	1	3	3	1	1	1	2	3	1
CO5	3	2	2	2	3	1	3	3	1	1	1	2	3	1
Avg	2.4	2	2.4	2	3	1	3	3	1	1	1	2	2.8	1

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

22PEE24	MODULATION CONTROL FOR POWER CONVERTERS			SEMESTER I		
PREREQUSITES		**CATEGORY**	**PE**	**Credit**		**3**
Power Electronics, Control System		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

To understand the modulation strategies & implementation of PWM controllers

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**
Overview of basic and advanced Power electronic converters, various applications, basics of utility power conversion, isolated and non-isolated converter circuits, types of power converter models.					
UNIT II	**STEADY STATE MODELING AND ANALYSIS**	**9**	**0**	**0**	**9**
Steady state converter analysis, Steady state modeling of the power converters, DC transformer model, loss modeling.					
UNIT III	**DYNAMIC MODELING AND ANALYSIS**	**9**	**0**	**0**	**9**
Dynamic modeling of the power converters, AC modeling of converters, state-space averaging, Transfer functions and frequency domain analysis, Extra Element Theorem.					
UNIT IV	**PULSE WIDTH MODULATION & CONTROL**	**9**	**0**	**0**	**9**
Pulse Width Modulation (PWM) control of power converters, voltage source and current source inverters, feedback control design, voltage mode and current mode control, control of inverters and rectifiers					
UNIT V	**CONTROLLER IMPLEMENTATION**	**9**	**0**	**0**	**9**
Analog and digital implementation of the controllers, advanced analysis and control techniques applied to power electronics converters.					
					Total (45L+0T)= 45 Periods

References:

1.	R. W. Erickson, D. Maksimovic, Fundamentals of Power Electronics, Kluwer Academic Publishers, 2004
2.	I. Batarseh, Power Electronic Circuits, Wiley, 2004
3.	J. Kassakian, M. F. Schlecht, and G. C. Verghese, Principles of Power Electronics, Addison-Wesley Publishing Company, 1991

Course Outcomes:

Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Remember the basic concepts of power electronic converters.	L1:Remembering
CO2	:	Understand and evaluate the steady state modeling	L5:Evaluating
CO3	:	Understand and evaluate the dynamic modeling	L5:Evaluating
CO4	:	Apply the concept of pulse width modulation for converters and inverters.	L3:Applying
CO5	:	Realize the implementation of controllers	L6:Creating

COURSE ARTICULATION MATRIX

COs/ POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO2	PSO 3
CO1	3	2	1	1	1		1	1	1	1	1	2	2	1
CO2	2	2	1	3	1		1	1	1	1	1	2	3	1
CO3	2	2	1	3	1		1	1	1	1	1	2	3	1
CO4	2	2	1	1	1		1	1	1	1	1	2	3	1
CO5	2	2	1	1	1	1	3	1	1	1	1	2	3	1
Avg	2.4	1	1	1.8	1	1	1.4	1	1	1	1	2	2.8	1
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)														

22PEE25	DESIGN OF POWER CONVERTERS				SEMESTER I		
PREREQUISTIES		**CATEGORY**	**PE**	**Credit**		**3**
Power Electronics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1. To know about the design concepts and flow.
2. To implements the device and circuit concepts for applications

UNIT I	**DESIGN OF UNCONTROLLED RECTIFIERS**	**9**	**0**	**0**	**9**
Selection of Rectifier topology – Pulse number – Power output - Selection of Diode – Voltage and Current Ratings – Selection of DC Filter – Design and Selection of Inductor and Capacitor with practical considerations					
UNIT II	**DESIGN OF CONTROLLED RECTIFIERS**	**9**	**0**	**0**	**9**
Selection of Rectifier topology - Pulse number – Power output – Reactive Power Requirements - Selection of SCR – Voltage and Current Ratings - Selection of DC Filter – Design and Selection of Inductor and Capacitor – Triggering Sequence and Sequence control for improved power factor operation.					
UNIT III	**DESIGN OF SWITCH MODE INVERTERS**	**9**	**0**	**0**	**9**
Selection of inverter topology – Power output – Harmonics – Reactive Power Requirements - Selection of Power Devices – Voltage and Current Ratings - Selection of output Filter – Design and Selection of Inductor and Capacitor – Different control strategy for various requirements.					
UNIT IV	**DESIGN OF SWITCH MODE DC-DC CONVERTERS**	**9**	**0**	**0**	**9**
Selection of converter topology – Power output – Performance parameters - Selection of Power Devices – Voltage and Current Ratings - Selection of Filter – Design and Selection of Inductor, Capacitor and ferrite transformers. Control strategies for various requirements.					
UNIT V	**DRIVERS, PROTECTION OF DEVICES AND CONVERTERS**	**9**	**0**	**0**	**9**
Driver requirements – Design of Drivers - Snubber – Polarized and Non-Polarized – Voltage Clamp-Thermal Resistances - Modes of Power dissipation – Heat sinking Design – Current Protection – Introduction to EMI.					
					Total (45L+0T)= 45 Periods

Reference Books:

1.	M.H.Rashid, 'Power Electronics: Circuits, Devices and Applications', Pearson Education, PHI 4th Edition, New Delhi, 2017.
2	Barry W. Williams - Principles and Elements of Power Electronics – Devices, Drivers, Applications and Passiv Components, ISBN 978-0-9553384-0-3.
3	https://onlinecourses.nptel.ac.in/noc22_ee33/preview

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand design concepts and flow	L2:Understanding
CO2	:	Choose suitable circuit topology for applications	L3:Applying
CO3	:	Select the appropriate power devices	L2:Understanding
CO4	:	Select and design the appropriate circuit to meet the design metrics	L5: Creating
CO5	:	Select the circuit configuration for electrical protection and scheme for thermal protection	L6:Evaluating

COURSE ARTICULATION MATRIX														
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	2	1	1	1	2		1	1	1	1	1	1	2	1
CO2	1	1	2	1	1		1	1	1	1	1	1	1	2
CO3	1	2	2	2	2		1	1	1	1	1	1	2	1
CO4	2	1	2	2	2		1	1	1	1	1	1	2	1
CO5	1	2	2	2	2		1	1	1	1	1	1	2	1
Avg	1.4	1.4	1.8	1.4	1.8	0	1	1	1	1	1	1	1.8	1.2
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)														

22PEE31	ADVANCED POWER QUALITY				SEMESTER II	
PREREQUISTIES		**CATEGORY**	**PE**	**Credit**		**3**
Analysis of Power converters		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To understand the various power quality issues.
2.	To understand the concept of power and power factor in single phase and three phase systems supplying non-linear loads
3.	To understand the conventional compensation techniques used for power factor correction and load voltage regulation.
4.	To understand the active compensation techniques used for power factor correction and load balancing.
5.	To understand the active compensation techniques used for load voltage regulation.

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Introduction – Characterization of Electric Power Quality: Transients, short duration and long duration voltage variations, Voltage imbalance, waveform distortion, Voltage fluctuations, Power frequency variation, Power acceptability curves – power quality problems: poor load power factor, Nonlinear and unbalanced loads. DC offset in loads, Notching in load voltage, Disturbance in supply voltage – Power quality standards.

UNIT II	**ANALYSIS OF SINGLE PHASE AND THREE PHASE SYSTEM**	**9**	**0**	**0**	**9**

Single phase circuits: single phase sinusoidal voltage source supplying nonlinear loads – single phase non sinusoidal voltage source supplying nonlinear loads, Three phase circuits: three phase sinusoidal balanced system – instantaneous real and reactive powers for Three phase circuits– symmetrical components- three phase non-sinusoidal balanced system- unbalanced and non-sinusoidal three phase system- Harmonic sources from commercial loads: SMPS-fluorescent lighting-ASD, Harmonic sources from Industrial loads: three-phase power converter- arcing devices, saturable devices.

UNIT III	**FUNDAMENTAL THEORY OF LOAD COMPENSATION**	**9**	**0**	**0**	**9**

Principle of load compensation – some practical aspects of compensator used as voltage regulator-Phase balancing and power factor correction of unbalanced load- a generalized approach for load compensation using symmetrical components, generating reference currents using instantaneous PQ theory.

UNIT IV	**REALISATION AND CONTROL OF DSTATCOM**	**9**	**0**	**0**	**9**

DSTATCOM structure- control of DSTATCOM connected to stiff source- DSTATCOM connected to weak supply point-DSTATCOM current control through phasor-DSTATCOM in Voltage control mode.

UNIT V	**SERIES COMPENSATION USING DVR**	**9**	**0**	**0**	**9**

Rectifier supported DVR – DC Capacitor supported DVR – Operating principle-characteristics for different load power factor and feeder resistance- mathematical description to compute DVR voltage – transient operation of DVR – realization of DVR using voltage source inverter- maximum compensation capacity of the DVR without real power support from DC-Link.
Unified power quality conditioner: Configuration - Types, structure and control characteristics.

Total (45T+0L)= 45 Periods

References:

1.	Arindam Ghosh and Gerard Ledwich, "Power Quality Enhancement Using Custom Power Devices", Kluwer Academic Publishers, 2002
2.	R. C. Dugan,Mark F McGranaghan, Surya Santoso, H.W.Beaty, "Electrical Power Systems Quality", McGraw Hill Publishers, New York, Second Edition, 2009.
3.	NPTEL course module of power quality in power distribution systems.
4.	A.J .Arrillaga, " Power system Harmonics",John willy & sons, Second Edition, 2003
5.	G.T.Heydt, "Electric Power Quality", McGraw-Hill Professional, 2007.
6.	Math H. Bollen, "Understanding Power Quality Problems", IEEE Press, 2000

Course Outcomes:			**Bloom's Taxonomy Mapped**
Upon completion of this course, the students will be able to:			
CO1	:	Recite the various power quality issues..	L1: Remembering
CO2	:	Analyze the single and three-phase circuits under non-sinusoidal and unbalanced load conditions	L4:Analyzing
CO3	:	Understand the conventional load compensation theories	L2:Understanding
CO4	:	Realize DSTATCOM for load compensation	L6:Creating
CO5	:	Design DVR and UPQC for power quality compensation	L6:Creating

COURSE ARTICULATION MATRIX														
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	2	1	3	3	1	1				1	1	3	1	1
CO2	2	3	2	1	1	1				1	1	3	1	1
CO3	2	3	2	3	2	1	1	1		1	1	3	2	1
CO4	2	3	2	2	2	2	1	1		2	1	3	2	2
CO5	2	3	2	2	2	2	1	1		2	1	3	2	2
Avg.	2	2.6	2.2	2.2	1.6	1.4	1	1	0	1.4	1	3	1.6	1.4
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)														

22PEE32	HARMONICS AND FILTERS FOR POWER ELECTRONIC CIRCUITS				SEMESTER II	
PREREQUISTIES		**CATEGORY**	**PE**	**Credit**		**C**
Analysis of Power converters		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To impart knowledge on the fundamentals of harmonics
2.	To understand the principle of operation of passive power filter
3.	To understand the principle of operation of shunt active power filter
4.	To understand the principle of operation of series active power filter
5.	To understand the principle of operation of hybrid active power filter

UNIT I	**FUNDAMENTALS OF HARMONICS**	**9**	**0**	**0**	**9**

The mechanism of harmonic generation – Sources of harmonics: commercial and industrial loads– Effects of harmonics – Factors influencing - development of harmonic standards – General harmonic indices – Applied harmonics: Harmonic evaluations on the utility system, Harmonic evaluation for end-user facilities – Harmonic study procedure – Useful tools for harmonic assessment: Fourier series, Fourier Transform, DFT, FFT, Hartley Transform and Wavelet Transform.

UNIT II	**PASSIVE POWER FILTER**	**9**	**0**	**0**	**9**

Classification: shunt, series – circuit configuration, principle of operation – Analysis and design simulation and performance – limitation – mitigation of resonance problem of passive filters with the power supply system.

UNIT III	**SHUNT ACTIVE POWER FILTER**	**9**	**0**	**0**	**9**

Classification, circuit configuration ,principle of operation and control, Analysis and design, modelling simulation and performance - numerical problems

UNIT IV	**SERIES ACTIVE POWER FILTER**	**9**	**0**	**0**	**9**

Classification, circuit configuration ,principle of operation and control, Analysis and design, modelling simulation and performance - numerical problems

UNIT V	**HYBRID ACTIVE POWER FILTER**	**9**	**0**	**0**	**9**

Classification, circuit configuration ,principle of operation and control, Analysis and design, modelling, simulation and performance - numerical problems

Total (45L+0T)= 45 Periods

References:

1.	Power quality problems and mitigation techniques “ Bhim Singh, Ambrish Chandra and Kamal Al-Haddad” John Wiley and Sons limited, First Edition 2015
2.	Electrical power system quality “Roger C. Dugan, Mark F.McGranaghan, Surya Santoso, H.Wayne Beaty” McGraw – Hill publications, Second Edition 2009.
3.	A.J.Arrillaga , “Power System Harmonics”, John Wiley and Sons Limited, Second Edition, 2003
4.	G.T.Heydt, “Electric Power Quality”, McGraw – Hill professional, 2007.

Course Outcomes:			**Bloom’s Taxonomy Mapped**
Upon completion of this course, the students will be able to:			
CO1	:	Understand the fundamentals of harmonics	L2:Understanding
CO2	:	Analyze and design of passive power filter	L4:Analyzing
CO3	:	Analyze and design of shunt active power filter	L4:Analyzing
CO4	:	Analyze and design of series active power filter	L4:Analyzing
CO5	:	Analyze and design of hybrid active power filter	L4:Analyzing

COURSE ARTICULATION MATRIX														
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	1	1	3	2	3							3	2	
CO2	1	3	2	2	1							3	2	
CO3	1	3	2	2	1							3	2	
CO4	1	3	2	2	1							3	2	
CO5	1	3	2	2	1							3	2	
Avg.	1	2.6	2.2	2	1.4	0	0	0	0	0	0	3	2	0
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)														

22PEE33	ENERGY CONSERVATION, AUDITING AND MANAGEMENT		SEMESTER II			
PREREQUISITES		CATEGORY	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Objectives:

1.	To understand the energy conservation concepts and electrical energy management.

UNIT I	**ENERGY SCENARIO**	**9**	**0**	**0**	**9**
Energy scenario of India – Present non-renewable energy scenario – Gross domestic product- Energy intensity – Current energy production and pricing – Energy security - Energy strategy for the future, air pollution, climate change. Energy Conservation Act-2001 and its features.					
UNIT II	**ENERGY CONSERVATION APPROACHES**	**9**	**0**	**0**	**9**
Basics Of Energy: Introduction – Work, power and energy – Electricity basics – Thermal energy basics – Energy units and conversions – Energy performance – Matching energy usage to requirement. Energy saving opportunities in electric motors, Benefits of Power factor improvement and its techniques-Shunt capacitor, Synchronous Condenser etc., Energy conservation by industrial drives, electric furnaces, ovens and boilers., Lighting techniques – Natural ,CFL, LED lighting sources and fittings.					
UNIT III	**ENERGY AUDITING**	**9**	**0**	**0**	**9**
Definition – Energy audit methodology : audit preparation, execution and reporting – Financial analysis – Sensitivity analysis – Project financing options - Energy monitoring and targeting –Energy audit of motors and lighting systems					
UNIT IV	**ENERGY MANAGEMENT**	**9**	**0**	**0**	**9**
Demand side management (DSM) – DSM planning – DSM techniques – Load management as a DSM strategy – energy conservation – tarrif options for DSM - Energy audit – instruments for energy audit – Energy audit for generation, distribution and utilization systems – economic analysis.					
UNIT V	**ENERGY EFFICIENT TECHNOLOGIES**	**9**	**0**	**0**	**9**
Maximum demand controllers - Automatic power factor controllers - Energy efficient motors -Soft starters with energy saver - Variable speed drives - Energy efficient transformers - Electronic ballast - Occupancy sensors - Energy efficient lighting controls - Energy saving potential of each technology.					
Total (45 L+ 0 T) = 45 Periods					

References:

1.	Soal Desai, “Handbook of Energy Audit”, 2015.
2.	S.C.Tripathy, “Utilization of Electrical Energy and Conservation”, McGraw Hill, 1980.
3.	Guide books for National Certification Examination for Energy Manager / Energy AuditorsBook-1, General Aspects (available online).
4.	Guide books for National Certification Examination for Energy Manager / Energy AuditorsBook-3, Electrical Utilities (available online)
5.	Murphy, W.R., and McKay, G., “Energy Management”, Butterworths Publications, 1981.
6.	Wayne C Tuner, “Energy Management Hand Book”, John Wiley and Sons, 6th edition, 2006.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Recognize the present energy scenario.	L2: Understanding
CO2	:	Identify various forms of energy.	L2: Understanding
CO3	:	Analyze energy management and energy auditing.	L4: Analysing
CO4	:	Apply various methods for improving energy efficiency.	L3: Applying
CO5	:	Identify the concepts of energy efficient devices.	L2: Understanding

COURSE ARTICULATION MATRIX														
COs\ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	2	2	2	1	1		3	1		1	3	2	3	1
CO2	2	2	3	3	1		3	1		2	3	2	2	1
CO3	2	2	2	2	2		1	1		3	3	2	3	1
CO4	2	3	2	3	3		2	2		2	2	2	2	1
CO5	2	2	3	3	3		2	3		2	2	2	2	1
Avg	2	2.2	2.4	2.4	2		2.2	1.6		2	2.6	2	2.4	1
3/ 2/ 1 – indicates strength of correlation (3- High, 2-Medium, 1-Low)														

22PEE34	SPECIAL ELECTRICAL MACHINES AND DRIVES		SEMESTER II			
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Power Electronics circuits, Electric Machines, Circuit Analysis and DSC		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

To understand the basic concepts of Special Electrical Machines for Speed and Torque Control using Power Electronic Circuits, sensors and Digital Controllers

UNIT I	**PERMANENT MAGNET BLDC MOTORS**	**9**	**0**	**0**	**9**
BLDC Construction - Driving Principle (Electronic Commutation) - Modelling - Voltage and Torque Equations - Torque ripple - Position Sensors - Position Sensing and Control - Commutation with QE - Position Alignment - Switching schemes - PAA and PSC control - Speed Control - Current Control - PWM Schemes - BSM and USM methods - Startup and reversal					
UNIT II	**PERMANENT MAGNET BLAC MOTORS**	**9**	**0**	**0**	**9**
Structure and Categories of PMSM - Modelling of PMSM - d-q axis model of PMSM - Voltage, Flux and Torque Equations - Vector control of SPMSM and IPMSM - d-q axis current regulators - PI gains for PMSM - Feed forward control - Speed estimation using encoder - Flux weakening control - Basics of Sensor-less control of PMSM					
UNIT III	**SWITCHED RELUCTANCE MOTORS**	**9**	**0**	**0**	**9**
SRM - Principle of operation - Equivalent Circuit - Power and Torque equation - operational characteristic - Phase excitation sequence - Control overview of SRM (Control Principle) - Current Control					
UNIT IV	**POWER CONVERTERS FOR SPECIAL MACHINE DRIVES**	**9**	**0**	**0**	**9**
Converters for BLDC, PMSM - Switching schemes - PWM schemes - Dead Time, Effects and Compensation - SRM - Asymmetric Bridge converter - (N+1) switch converter - C-Dump converter - N switch converter.					
UNIT V	**SENSING ELEMENTS AND INTERFACE FOR SPECIAL ELECTRIC MACHINE DRIVES**	**9**	**0**	**0**	**9**
Current Sensors, their position in circuit and interface with DSC - Voltage Sensors and interface with DSC - Position/Speed Sensors and interface with DSC - Quadrature Encoder Interface.					
					Total (45L+0T) = 45 Periods

References:

1.	Control of Electric Machine Drive Systems - Seung-Ki Sul – John Wiley IEEE – 2011
2.	Electrical Machine Drives Control - Juha Pyrhönen et al. – Wiley – 2016
3.	Advanced Electric Drives Analysis - Ned Mohan – Wiley – 2014
4.	AC Motor Control and Electrical Vehicle Applications Second Edition - Kwang Hee Nam Taylor & Francis - 2019
5.	Electric Vehicle Machines and Drives – Design Analysis and Application – K.T. Chau – Wiley 2015
6.	Electric Motor Control - Sang-Hoon Kim- Elsevier – 2017

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the theory of operation and control of BLDC Machines	L2: Understanding
CO2	:	Analyze the modeling of Special Machines and their control	L4: Analyzing
CO3	:	Analyze the operation and characteristics of Switched Reluctance motor	L4: Analyzing
CO4	:	Apply the suitable power converter for special electrical machines	L3: Applying
CO5	:	Identify the necessity of sensor and interface with DSC for electrical machine drives	L3:Applying

COURSE ARTICULATION MATRIX														
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	1	1	1	1	1	1	3	2	1	1	1	3	3	1
CO2	1	2	2	3	1	2	2	1	1	2	1	2	3	2
CO3	1	2	2	2	2	1	1	1	2	3	1	3	2	2
CO4	2	3	2	3	3	1	2	2	1	2	2	2	3	1
CO5	2	2	3	3	3	1	2	3	1	2	2	2	2	2
Avg	1.40	2.00	2.00	2.40	2.00	1.20	2.00	1.80	1.20	2.00	1.40	2.40	2.60	1.60
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)														

22PEE35	DIGITAL SIMULATION OF POWER ELECTRONICS SYSTEM		SEMESTER II			
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Modeling Of Electrical Machines Electrical Drives		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:					
To provide knowledge on modeling and simulation of power electronic circuits and systems					
UNIT I	**NUMERICAL METHODS IN PASSIVE COMPONENTS**	**9**	**0**	**0**	**9**
Review of numerical methods. Application of numerical methods to solve transients in D.C. Switched R, L, R-L, R-C and R-L-C circuits. Extension to AC circuits.					
UNIT II	**SIMULATION AND MODELLING OF ACTIVE AND PASSIVE COMPONENTS**	**9**	**0**	**0**	**9**
Modeling of diode in simulation. Diode with R, R-L, R-C and R-L-C load with ac supply. Modeling of SCR, TRIAC, IGBT and Power Transistors in simulation. Application of numerical methods to R, L, C circuits with power electronic switches. Simulation of gate/base drive circuits, simulation of snubber circuits.					
UNIT III	**STATE SPACE MODELLING AND SIMULATION OF LINEAR SYSTEMS**	**9**	**0**	**0**	**9**
State space modeling and simulation of linear systems. Introduction to electrical machine modeling: induction, DC, and synchronous machines, simulation of basic electric drives, stability aspects.					
UNIT IV	**SIMULATION OF CONVERTERS AND DC DRIVES**	**9**	**0**	**0**	**9**
Simulation of single phase and three phase uncontrolled and controlled (SCR) rectifiers, converters with self commutated devices- simulation of power factor correction schemes, Simulation of converter fed dc motor drives ,Simulation of thyristor choppers with voltage, current and load commutation schemes, Simulation of chopper fed dc motor.					
UNIT V	**SIMULATION OF INVERTERS AND AC DRIVES**	**9**	**0**	**0**	**9**
Simulation of single and three phase inverters with thyristors and self-commutated devices, Space vector representation, pulse-width modulation methods for voltage control, waveform control. Simulation of inverter fed induction motor drives.					
Total (L+T)= 45 Periods					

Reference Books:	
1.	Simulink Reference Manual, Math works, USA.
2.	Robert Ericson, ‘Fundamentals of Power Electronics’, Chapman & Hall, 1997.
3.	Issa Batarseh, ‘Power Electronic Circuits’, John Wiley, 2004Simulink Reference Manual , Math works, USA.

Course Outcomes:			
Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Understand the concepts of modeling and simulation of power electronics and drives circuits.	Knowledge
CO2	:	Develop algorithm and software models for power electronics and drives applications	Realize
CO3	:	Analyze the transient and steady performance of the designed models.	Analysis
CO4	:	Choose suitable devices or models for appropriate applications	Evaluate
CO5	:	Identify suitable hardware components for implementation	Analysis

COURSE ARTICULATION MATRIX															
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	2	2	2	2	1	2	1	2	1	1		2	1	1
CO2	3	3	3	3	3	3	2	2	2	1	1		3	2	1
CO3	3	3	3	2	2	2	3	3	2	1	1		3	3	1
CO4	3	3	2	3	3	2	2	2	1	2	1	2	3	3	1
CO5	3	2	2	2	2	1	2	1	2	1	1	2	3	3	1
Avg	3	2.6	2.4	2.4	2.4	1.8	2.2	1.8	1.8	1.2	1	2	2.8	2.4	1
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)															

22PEE36	MODELING OF SWITCHED MODE POWER CONVERTERS		SEMESTER II			
PREREQUISTIES		**CATEGORY**	**PE**	**Credit**		**3**
Analysis of Power Converters.		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To introduce the basics of DC –DC converters
2.	To analyze the dynamic analysis of DC-DC converters
3.	To analyze the various types of single and multi-switch converters.
4.	To study the Controller Design of converters.

UNIT I	**DYNAMIC ANALYSIS OF DC-DC CONVERTERS.**	**9**	**0**	**0**	**9**
Formulation of dynamic equation of buck and boost converters, averaged circuit models, linearization technique, small-signal model and converter transfer functions.					
UNIT II	**MODELLING AND ANALYSIS OF SINGLE SWITCH ISLOATED CONVERTERS**	**9**	**0**	**0**	**9**
Requirement for isolation in the switch-mode converters, transformer connection, Forward and flyback converters, power circuit and steady-state analysis. Push-Pull Converters-Power circuit and steady-state analysis, utilization of magnetic circuits in single switch and push-pull topologies.					
UNIT III	**MODELLING AND ANALYSIS OF MULTI SWITCH ISLOATED CONVERTERS**	**9**	**0**	**0**	**9**
Half bridge and full-bridge converters, Power circuit and steady state analysis, utilization of magnetic circuits and comparison with previous topologies.					
UNIT IV	**DESIGN OF MAGNETIC COMPONENT**	**9**	**0**	**0**	**9**
Magnetic core materials and performance; basic inductor and transformer design; practical magnetic design; design aspects to be considered for designing transformers for specific applications – flyback, push- pull, bridge , forward converters					
UNIT V	**CONTROLLER DESIGN**	**9**	**0**	**0**	**9**
Review of frequency-domain analysis of linear time-invariant systems, concept of bode plot, phase and gain margins bandwidth, controller specifications, proportional (P), proportional plus integral (PI), proportional plus integral plus integra controller (PID), selection of controller parameters.					
Total (45L+0T)= 45 Periods					

References :

1.	Robert W. Erickson and Dragan Maksimovic, 'Fundamentals of Power Electronics', Springer, 2nd Edition, 2001.
2.	N Mohan, T M Undeland and W P Robbins, "Power Electronics: Converters, Applications and Design", Wiley, Third Edition.
3.	V.Ramanarayanan Course Material on Switched Mode Power Conversion, Department of Electrical Engineering, Indian Institute of Science, Bangalore 560012
4.	Middlebrook, R. D. (Robert David), and Slobodan Cuk, Advances in Switched-Mode Power Conversion, Volumes I and II, 2nd Edition, TESLA co, 1983.
5.	NPTEL material by Dr. Umanand and Dr. V. Ramnarayanan, IISC Bangalore.
6.	Muhammad H. Rashid - Power Electronics Devices, Circuits, and Applications 4 Edition, Pearson 2014.
7.	Barry W. Williams - Principles and Elements of Power Electronics – Devices, Drivers, Applications and Passive Components, ISBN 978-0-9553384-0-3.
8.	www.onlinecourses.nptel.ac.in/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Acquire knowledge about the Non isolated converts and their dynamic analysis.	L1: Remembering
CO2	:	Analyze the steady state operation of various single switch and multi switch isolated converters	L4: Analyzing
CO3	:	Understand the power circuit diagram of isolated converters.	L3: Understanding
CO4	:	Design of magnetic component for various converters..	L4:Creating
CO5	:	Analyze and Understand the different types of controller design and apply to Converters	L3& L4 : Analyzing and understanding

COURSE ARTICULATION MATRIX														
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	2	1	1	1	3		1	1				1	2	1
CO2	1		2	1	1						1	1	1	2
CO3	1	2	3	2	3	1		1			1	1	2	1
CO4	2	1	3	3	2	1	1	1			1	1	2	1
CO5	1	3	2	2	3	2	1	1			1	1	2	1
Avg	1.40	1.75	2.20	1.80	2.40	1.3	1	1	0.00	0.00	1	1.00	1.80	1.20
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)														

22PEE41	SOLAR PHOTO VOLTAIC SYSTEM		SEMESTER II			
PREREQUISTIES		**CATEGORY**	**PE**	**Credit**		**3**
Renewable Energy Systems		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:					
To learn the fundamentals, design and application of solar photovoltaic systems for power generation on small and large scale electrification..					
UNIT I	**SOLAR PV MODULES**	**9**	**0**	**0**	**9**
Solar PV modules from Solar cells – Mismatch in Series and Parallel connection – Design an structure of PV modules- I-V Equation and characteristics of a PV module – Power Curve of PV module –Effect of solar Irradiation and Temperature – PV arrays - maximum power point					
UNIT II	**PV SYSTEM COMPONENTS**	**9**	**0**	**0**	**9**
PV arrays and its installation - Batteries for PV System: Factors affecting Battery Performance- Types of Batteries- Comparison of batteries - Charge controllers and its types – Converters: DC to DC converters and its types – DC to AC converters and its types – Maximum Power Point Tracking					
UNIT III	**DESIGN OF PV SYSTEMS**	**9**	**0**	**0**	**9**
Stand-alone PV system Configuration - Design Methodology – Case studies with DC Load, AC Load and hybrid loads - Sizing of PV systems – Grid Connected PV System: Configuration and Working.					
UNIT IV	**MODELING & ANALYSIS**	**9**	**0**	**0**	**9**
Dynamic PV models - Large PV units modeling and analysis - PV units and impact to distribution grid Systems - Design and Analysis procedures - Guideline for integration studies - determination of acceptable level of penetration of PV units.					
UNIT V	**PV SYSTEM APPLICATIONS**	**9**	**0**	**0**	**9**
Home lighting and other Appliances - solar water pumping systems- Socio-economic and environmental merits of photovoltaic systems- solar cars – solar aircraft - space solar power satellites					
					Total (45L) = 45 Periods

References:	
1.	Chetan Singh Solanki., Solar Photovoltaic: “Fundamentals, Technologies and Application”, PHI Learning Pvt., Ltd., 2009.
2.	Jha .A.R, “Solar Cell Technology and Applications”, CRC Press, 2010.
3.	John R. Balfour, Michael L. Shaw, Sharlave Jarosek., “Introduction to Photovoltaics”, Jones & Bartlett Publishers, Burlington, 2011
4.	Partain .L.D, Fraas L.M., “Solar Cells and Their Applications”, 2nd ed., Wiley,2010.
5.	Sukhatme .S.P, Nayak .J.K, “Solar Energy”, Tata McGraw Hill Education Private Limited, New Delhi, 2010

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Summarize the fundamental of PV modules and arrays.	L2: Understanding
CO2	:	Illustrate the components and its suitability based on its operation.	L4:Analysing
CO3	:	Select the appropriate configuration and sizing.	L4:Analysing
CO4	:	Analyze the off grid /on grid PV system.	L4:Analysing
CO5	:	Apply the PV system for different applications.	L3: Applying

COURSE ARTICULATION MATRIX													
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	2	2	2	2	1	1	1	1	1	2	2	1	2
CO2	3	2	2	2	2	1	1	1	1	1	1	2	1	1
CO3	2	2	2	2	2	1	1	1	1	1	1	2	1	1
CO4	2	3	3	3	3	1	1	1	1	1	2	3	2	1
CO5	2	2	3	3	2	1	1	1	1	1	2	3	1	1
Avg	2.4	2.2	2.4	2.4	2.2	1.0	1.0	1.0	1.0	1.0	1.6	2.4	1.3	1.2

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

22PEE42	OPTIMIZATION TECHNIQUES					SEMESTER II		
PREREQUISITES		CATEGORY	PE		Credit		3
		Hours/Week	L	T		P	TH
			3	0		0	3

Course Objectives:

1. To understand the fundamentals of optimization techniques, and their applications to solve engineering problems.

UNIT I	INTRODUCTION	9	0	0	9

Concepts of optimization- Engineering applications - Statement of optimization problem - Classification - Classical Optimization Techniques: Single and multivariable optimization- Optimization with equality and inequality constraints.

UNIT II	LINEAR PROGRAMMING	9	0	0	9

Linear programming: Standard form-Geometry of LP problems-Theorem of LP - Relation to convexity - formulation of LP problems - simplex method and algorithm - Matrix form- two phase method- Duality - dual simplex method- Decomposition- Sensitivity analysis.

UNIT III	NON-LINEAR PROGRAMMING:	9	0	0	9

Steepest descent method, conjugates gradient method, Newton's Method, Sequential quadratic programming, Penalty function method, augmented Lagrange multiplier method.

UNIT IV	DYNAMIC PROGRAMMING	9	0	0	9

Multistage decision processes, concept of sub-optimization and principle of optimality, Recursive relations, Integer Linear programming, Branch and bound algorithm: Multistage decision process- Concept of sub optimization and principle of optimality - Computational procedure- Engineering applications.

UNIT V	GENETIC ALGORITHM	9	0	0	9

Introduction to genetic Algorithm, working principle, coding of variables, fitness function, GA operators; Similarities and differences between GA and traditional methods; Unconstrained and constrained optimization using Genetic Algorithm, real coded GA, Advanced GA, global optimization using GA.

Total (45 L+ 0 T) = 45 Periods

References:

1. Rao, Singaresu, S., "Engineering Optimization – Theory & Practice", New Age International (P) Limited, New Delhi, 2000.
2. Kalyanamoy Deb, "Optimization for Engineering design algorithms and Examples", Prentice Hall of India Pvt. 1995.
3. Luenberger,G, "Introduction of Linear and Non-Linear Programming" , Wesley Publishing Company, 2011.
1. Hamdy A. Taha, ―Operations Research - An Introduction‖, MacMillan Co., Eighth Edition 2010.
2. Ronald L Rardin, ―Optimisation in Operations Research‖ Pearson Education Asia, First Indian reprint, 2013

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Recognize the basics of optimization	L2: Understanding
CO2	:	Formulate Linear Programming optimization problems	L4: Analysing
CO3	:	Formulate unconstraint and constraint optimization problems	L4: Analysing
CO4	:	Apply optimization tools to engineering applications	L3: Applying
CO5	:	Analyze the optimization problems using Genetic Algorithm	L4: Analysing

COURSE ARTICULATION MATRIX

COs\POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	2	2	2	1	1		3	1		1	3	2	3	1
CO2	2	2	3	3	1		3	1		2	3	2	2	1
CO3	2	2	2	2	2		1	1		3	3	2	3	1
CO4	2	3	2	3	3		2	2		2	2	2	2	1
CO5	2	2	3	3	3		2	3		2	2	2	2	1
Avg	2	2.2	2.4	2.4	2		2.2	1.6		2	2.6	2	2.4	1

3/ 2/ 1 – indicates strength of correlation (3- High, 2-Medium, 1-Low)

22PEE43	DYNAMICS OF POWER CONVERTERS			SEMESTER II		
PREREQUISTIES		**CATEGORY**	**PE**	**Credit**		**3**
Analysis of Power Converters.		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To study an overview of power semiconductor devices.
2.	To obtain the knowledge of controlled rectifiers.
3.	To acquire the principles of DC-DC converter.
4.	To understand the principles of inverters and ac voltage controllers.

UNIT I	**INTRODUCTION TO DYNAMIC ANALYSIS**	**9**	**0**	**0**	**9**
Introduction- Generalized Dynamic Representations for Voltage fed and Current fed DC-DC converters- Source and Load Interactions- Generalized Dynamic Representations for three-phase voltage-fed and current fed rectifiers, Three-phase voltage fed and current-fed inverters-closed loop dynamics- Generalized Cascaded Control Schemes - Generalized Impedance-Based Stability					
UNIT II	**DYNAMIC MODELING AND CONTROL OF VOLTAGE FED DC-DC CONVERTERS**	**9**	**0**	**0**	**9**
Direct-on-Time Control- DOT-controlled converter at open loop with a PWM modulator; Generalized Modeling Technique; Dynamic model of Buck-converter -power stages- topological sub circuit structures- state space equations- Linearized state space model; Peak Current Mode Control principles- Development of Duty-Ratio Constraints- PCM State Spaces and Transfer Functions					
UNIT III	**DYNAMIC MODELING AND CONTROL OF CURRENT FED DC-DC CONVERTERS**	**9**	**0**	**0**	**9**
Duality Transformation Basics- Duality-Transformed Converters- Voltage-fed and Current-fed buck, boost converters; Dynamic equivalent circuits of current fed current-output converter and current-fed voltage output converter; Dynamic model of current fed Buck , Boost Converters; Duty-Ratio Constraints under PCM Control- PCM-controlled current-fed buck, boost power-stage converter.					
UNIT IV	**DYNAMICS OF THREE PHASE INVERTERS**	**9**	**0**	**0**	**9**
Dynamic Model of Voltage-Fed Inverter- Equivalent switching circuit and average model - Linearized State-Space and Open-Loop Dynamics; Dynamic Model of Current-Fed Inverter- Equivalent switching circuit and average model- Linearized Model and Open-Loop Dynamics Control Design of Grid-Connected Three-Phase Inverters- Synchronous Reference Frame Phase Locked Loop- Linearized Model of SRF-PLL- Control Design of SRF-PLL.					
UNIT V	**DYNAMIC MODELING OF THREE PHASE ACTIVE RECTIFIERS AND STABILITY ASSESSMENT.**	**9**	**0**	**0**	**9**
Three Phase active rectifier -Power stage and Equivalent switch matrix- Equivalent circuit model- State space model- Control o active rectifier using transfer matrices- Open-Loop and closed loop control scheme.					
Total (45L+0T)= 45 Periods					

References :

1.	Teuvo Suntio, “Power Electronic Converters:Dynamics and Control in Conventional and Renewable Energ Applications”, Wiley-VCH Verlag GmbH & Co. KGaA, Germany, 2018.
2.	Teuvo Suntio, Dynamic Profile of Switched-Mode Converter Modeling, Analysis and Control, Wiley-VCH Verlag GmbH & Co. KGaA, Germany, 2009.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Know the dynamic representations of power converters	L1: Remembering
CO2	:	Make a dynamic model of DC-DC converter	L6:Creating
CO3	:	Select appropriate control scheme for DC-DC converter with its dynamic model	L5:Evaluating
CO4	:	Develop state space model for three phase converters	L3:Applying
CO5	:	Design a suitable controller for for three phase converters	L5: Evaluating.

COURSE ARTICULATION MATRIX														
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	2	1	1	1	3		1	1				1	2	1
CO2	1		2	1	1						1	1	1	2
CO3	1	2	3	2	3	1		1			1	1	2	1
CO4	2	1	3	3	2	1	1	1			1	1	2	1
CO5	1	3	2	2	3	2	1	1			1	1	2	1
Avg	1.40	1.75	2.20	1.80	2.40	1.3	1	1	0.00	0.00	1	1.00	1.80	1.20
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)														

22PEE44	WIND ENERGY CONVERSION SYSTEMS			SEMESTER II			
PREREQUISTIES		**CATEGORY**		**PE**	**Credit**		**3**
Renewable Energy Systems		**Hours/Week**		**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

To learn the fundamentals, design and application of wind energy conversion systems for small and large scale electrification.

		L	T	P	TH
UNIT I	**WIND RESOURCE ASSESSMENT AND WEC COMPONENTS**	**9**	**0**	**0**	**9**
Wind regime modelling - measurement instruments - Weibull parameters- height dependency- wind energy forecast-Components of WECS-WECS schemes - Power obtained from wind - simple momentum theory- Power coefficient - Sabinin's theory - Aerodynamics of Wind turbine					
UNIT II	**WIND TURBINE**	**9**	**0**	**0**	**9**
HAWT-VAWT-Power developed-Thrust-Efficiency-Rotor selection-Rotor design considerations- Tip speed ratio-No. of Blades-Blade profile-Power Regulation-yaw control-Pitch angle control- stall control-Schemes for maximum power extractions - Power-wind speed characteristics					
UNIT III	**FIXED SPEED WTGS**	**9**	**0**	**0**	**9**
Fixed speed constant frequency systems -Choice of Generators- Deciding factors-Synchronous Generator-Squirrel Cage Induction Generator- Model of Wind Speed- Model wind turbine rotor – Drive Train model					
UNIT IV	**VARIABLE SPEED WTGS**	**9**	**0**	**0**	**9**
Variable speed constant frequency systems synchronous generator- DFIG- PMSG -Variable speed generators modelling – Variable speed variable frequency schemes- Grid Integration of wind energy systems to electrical networks, converters, inverters - wind energy storage solutions.					
UNIT V	**DESIGN REQUIREMENTS**	**9**	**0**	**0**	**9**
Components and strategies - Site selection and turbine spacing - rotor selection - **Control systems** requirements - testing - noise issues - Annual Energy Output (AEO)- optimal placement of wind turbine in a wind park, ICT based monitoring and control of wind farms.					
					Total (45L) = 45 Periods

References:

1.	L.L.Freris "Wind Energy conversion Systems", Prentice Hall, 1990
2.	Ion Boldea, "Variable speed generators", Taylor & Francis group, 2006.
3.	S.Heir "Grid Integration of WECS", Wiley 1998
4.	N. Jenkins," Wind Energy Technology" John Wiley & Sons,1997

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Summarize the methods of harnessing the wind energy.	L2:Understanding
CO2	:	Illustrate the components of WECS and its suitability.	L4:Analysing
CO3	:	Analyze the maximum power.from Wind turbine.	L4:Analysing
CO4	:	Categorize the performance of different generators.	L4:Analysing
CO5	:	Model and apply control techniques for WTGS for different speeds. .	L3:Applying

COURSE ARTICULATION MATRIX

COs/ POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	3	2	2	2	2	1	1	1	1	1	1	2	1	1
CO2	2	3	3	2	2	1	1	1	1	1	1	3	1	1
CO3	3	2	2	2	3	1	1	1	1	1	1	2	2	1
CO4	2	2	2	2	2	1	1	1	1	1	1	2	1	1
CO5	2	3	3	2	2	1	1	1	1	1	1	3	1	1
Avg	2.4	2.4	2.4	2.0	2.2	1.0	1.0	1.0	1.0	1.0	1.0	1.2	2.3	1.3

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

22PEE45	POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEM		SEMESTER II			
PREREQUISTIES		**CATEGORY**	**PE**	**Credit**		**3**
Nil		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To understand the principle of solar and wind energy conversion systems.
2.	To know inverter structures need for solar and wind energy systems.
3.	To introduce grid integration methods for solar and wind energy systems.

UNIT I	**SOLAR PHOTOVOLTAIC SYSTEM**	**9**	**0**	**0**	**9**
Sustainable Sun's Energy – Advantages and Conversion Challenges –Solar Cell- operation- I-V Equation and characteristics- Solar PV Modules-Design and Structure of PV module- I-V Equation, Power curve and rating-Effect of Solar Irradiation and Temperature- Maximum Power Point Tracking-Perturb and Observe algorithm-Incremental conductance algorithms.					
UNIT II	**WIND ENERGY CONVERSION SYSTEM**	**9**	**0**	**0**	**9**
Principle and Components of Wind Energy Conversion System- Power Conversion and Power Coefficient -Self Excited Induction Generator (SEIG) - Theory of self excitation – Permanent magnet synchronous generator (PMSG) - Autonomous Generation Systems with Permanent Magnet Generators					
UNIT III	**FUEL CELL**	**9**	**0**	**0**	**9**
Introduction- Types- Commercial and Manufacturing Issues - Constructional Features of Proton Exchange-Membrane Fuel Cells; Advantages and Disadvantages of Fuel Cells - Fuel Cell Equivalent Circuit; Aspects of Hydrogen as Fuel, Introduction to Bloom energy.					
UNIT IV	**INVERTER STRUCTURES FOR RENEWABLE ENERGY SYSTEM**	**9**	**0**	**0**	**9**
Introduction- Inverter Structure, control and operation- H5 Inverter - HERIC Inverter - Neutral Point Clamped (NPC) Half-Bridge Inverter- H-Bridge Based Boosting Inverter - Three-Phase solar PV Inverters- Two-level back-to-back PWM Inverter-Three-level back-to-back PWM Inverter- Generic control structure for a PV inverter.					
UNIT V	**GRID INTEGRATION OF GREEN ENERGY SYSTEMS**	**9**	**0**	**0**	**9**
Generic structure for grid connected PV system- Single stage grid connected PV system-Control scheme- Grid Synchronizatio Techniques for Single-Phase Systems- Grid Synchronization Using a Phase-Locked Loop-Control structure of WES- Generato Side Control- WES Grid Control- Influence of active and reactive power injection by WES.					
Total (45L+0T)= 45 Periods					

References:

1.	Chetan Singh Solanki, " Solar Photovoltaics: Fundamentals, Technologies and Applications", PHI Learning Private Limited, New Delhi, 2016.
2.	Remus Teodorescu, "Grid converters for photovoltaic and wind power systems ", A John Wiley and Sons Ltd Publication, 2011.
3.	E.Acha and VG Agilidis," Power Electronic Control In Electrical Systems",Elsevier India Pvt Ltd, Ist Edition, 2006.
4.	Felix A. Farret, M. Godoy Simo` es, Integration of Alternative Sources of Energy, John Wiley & Sons, 2006.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Know solar, fuel cell and wind energy conversion principles.	L2: Understanding
CO2	:	Select suitable power Converters for green energy systems.	L3: Applying
CO3	:	Design wind and solar based power plants.	L5: Creating
CO4	:	Design an appropriate system for standalone and grid connected operation.	L5: Creating
CO5	:	Know grid integration challenges with fuel cell, solar and wind energy systems.	L3: Applying

COURSE ARTICULATION MATRIX														
COs/ POs	**PO 1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO1 0**	**PO1 1**	**PSO1**	**PSO 2**	**PSO 3**
CO1		1			1	3			1	2		1	1	1
CO2	2	3								1		1	3	3
CO3			2	1			1	2			1	2	2	2
CO4			2				1	2			1	3	2	3
CO5			1	2					1			2	3	3
Avg	2	2	1.67	1.5	1		1	2	1	1.5	1	1.8	2.2	2.4

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

22PEE51	SMART GRID TECHNOLOGY			SEMESTER III		
PREREQUISTIES		**CATEGORY**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To provide exposure of advanced power electronic converters to be utilized by the industries and utilities

UNIT I	**SMART GRID ARCHITECTURE**	**9**	**0**	**0**	**9**
Definitions and Features for Smart Grid, Characteristics of Smart Grid, Smart grid infrastructure with its components, Smart Grid Enabling Technologies, Transformation from Traditional Grid to Smart Grid, Stages for Grid Modernization, Smart Grid Challenges					
UNIT II	**COMMUNICATION AND INFORMATION SECURITY**	**9**	**0**	**0**	**9**
Requirements of Smart Grid Communications, Communication infrastructure for the Smart Grid, communication technologies for Smart Grid, Information Layer of Smart Grid, SG Security Objectives, Cyber Security Requirements for Smart Grid					
UNIT III	**CONTROL AND AUTOMATION TECHNOLOGIES**	**9**	**0**	**0**	**9**
Smart metering: Benefits, Architecture, Key components and operation, communications architecture for smart metering, Demand-side integration (DSI): Definitions and services provided by DSI, Substation automation equipment: architecture, components and functions, Intelligent electronic devices (IED), Relay IED and other types, Bay controller.					
UNIT IV	**ENERGY STORAGE SYSTEMS FOR SMART GRID**	**9**	**0**	**0**	**9**
Structure of Energy Storage System, Techno- Economic Characteristics of Energy Storage Systems, Energy Storage Systems Classification and Description, Smart grid energy storage applications at different voltage levels, Power Conditioning System for Interfacing Energy Storage Technologies with Smart Grid.					
UNIT V	**GREEN ENERGY INTEGRATION IN SMART GRID**	**9**	**0**	**0**	**9**
Sustainable energy options for the smart grid- Solar PV System, Wind Energy and Fuel Cell: Conversion and Power electronic technology for grid integration, Penetration and variability issues associated with sustainable energy technology, PHEV technology, Impact of PHEV on the Smart Grid.					
Total (45L+0T)= 45 Periods					

References:

1.	James Momoh “SMART GRID Fundamentals of Design and Analysis”, Wiley India, 2015.
2.	Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, “Smart Grid: Technology and Applications”, Wiley, 2012.
3.	Mini S. Thomas, John D McDonald, ‘Power System SCADA and Smart Grids’, CRC Press, 2015
4.	https://onlinecourses.nptel.ac.in/noc23_ee60

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Level**
CO1	:	Explain the structure of Smart Grid and its present developments.	L2-Understanding
CO2	:	Select the suitable communication networks and information security for smart grid	L4-Analyzng
CO3	:	Apply the principle of automation and control infrastructure in Smart Grid	L3-Applying
CO4	:	Use an energy storage system in Smart Grid with its integration	L3-Applying
CO5	:	Outline the smart energy resources and its integration with Smart Grid	L4-Analyzing

COURSE ARTICULATION MATRIX														
COs/ POs	**PO1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	2	1	2			1	2	2	2		1	2	2	1
CO2	1				2	1		1	1	3		2	1	
CO3	2	1	2	2	1		2	1		2	2	1	2	1
CO4	3		3	1	2				1	1	2	2	2	1
CO5	1	3		1		1	1	1	2		1	2	1	
Avg	1.80	1.67	2.33	1.33	1.67	1.00	1.67	1.25	1.50	2.00	1.50	1.80	1.60	1.00
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)														

22PEE52	DISTRIBUTED GENERATION AND MICROGRID				SEMESTER III	
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Nil		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To impart knowledge on distributed generation technologies, impact on grid integration, and microgrid operation and control.

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**
Conventional power generation: advantages and disadvantages, Energy crises, Non- conventional energy (NCE) resources: review of Solar PV, Wind Energy systems, Fuel Cells, micro-turbines, biomass, and tidal sources.					
UNIT II	**DISTRIBUTED GENERATIONS**	**9**	**0**	**0**	**9**
Concept of distributed generations, topologies, selection of sources, regulatory standards/ framework, Standards for interconnecting Distributed resources to electric power systems: IEEE 1547. DG installation classes, security issues in DG implementations. Energy storage elements: Batteries, ultra-capacitors, flywheels. Captive power plants.					
UNIT III	**IMPACT OF GRID INTEGRATION**	**9**	**0**	**0**	**9**
Requirements for grid interconnection, limits on operational parameters: voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues. Impact of grid integration with NCE sources on existing power system: reliability, stability and power quality issues.					
UNIT IV	**BASICS OF A MICROGRID**	**9**	**0**	**0**	**9**
Concept and definition of microgrid, microgrid drivers and benefits, review of sources of microgrids, typical structure and configuration of a microgrid, AC and DC microgrids, Power Electronics interfaces in DC and AC microgrids.					
UNIT V	**CONTROL AND OPERATION OF MICROGRID**	**9**	**0**	**0**	**9**
Modes of operation and control of microgrid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques, microgrid communication infrastructure, Power quality issues in microgrids, regulatory standards, Microgrid economics, Introduction to smart microgrids.					
					Total (45 L + 0 T) = 45 Periods

Reference Books:

1.	Lee Willis, H., and Walter G. Scott, "Distributed Power Generation – Planning and Evaluation", Marcel Decker Press, 2000.
2.	Godoy Simoes, M., and Felix A.Farret, "Renewable Energy Systems – Design and Analysis with Induction Generators", CRC Press, 2004.
3.	Robert Lasseter, Paolo Piagi, "Micro-grid: A Conceptual Solution", PESC 2004, June 2004.
4.	John Twidell and Tony Weir, "Renewable Energy Resources" Taylor and Francis Publications, 2005.
5.	Dorin Neacsu, "Power Switching Converters: Medium and High Power", CRC Press, Taylor & Francis, 2006.
6.	Amirnaser Yezdani, and Reza Iravani, "Voltage Source Converters in Power Systems: Modeling, Control and Applications", IEEE John Wiley Publications, 2009.
7.	Katiraei, F., and Iravani, M.R., "Transients of a Micro-Grid System with Multiple Distributed Energy Resources", International Conference on Power Systems Transients (IPST'05) in Montreal, Canada on June 19-23, 2005.
8.	Ye, Z., Walling, R., Miller, N., Du, P., and Nelson, K., "Facility Microgrids", General Electric Global Research Center, Niskayuna, New York, Subcontract report, May 2005.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Identify various forms of energy sources.	L2: Understanding
CO2	:	Recognize various DG technologies.	L2: Understanding
CO3	:	Analyse the impact on grid while integrating DGs.	L4: Analysing
CO4	:	Demonstrate the concepts of microgrids.	L3: Applying
CO5	:	Categorize various microgrid control schemes.	L4: Analysing

COURSE ARTICULATION MATRIX

COs\POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO 1	1	3	3	3	2		3	1		1	2	2	3	1
CO 2	1	3	3	3	2		3	1		1	2	2	2	1
CO 3	1	2	2	2	2		3	1		1	1	1	3	1
CO 4	1	2	3	2	2		3	1		1	2	2	2	1
CO 5	1	2	2	2	2		2	1		1	1	2	2	1
Avg	1	2.4	2.6	2.4	2		2.8	1		1	1.4	1.8	2.4	1

3/ 2/ 1 – indicates strength of correlation (3- High, 2-Medium, 1-Low)

22PEE53	FACTS CONTROLLERS			SEMESTER III		
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Power Systems		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To learn the active and reactive power flow control in power system
2.	To understand the need for static shunt and series compensators and develop different control strategies for compensation.
3.	To analyze the principle of operation of UPFC and IPFC.
4.	To understand the concept of coordination of FACTS controllers.

UNIT I	**FACTS CONCEPTS**	**9**	**0**	**0**	**9**

Reactive power flow control in power systems-Control of dynamic power imbalances in power system-Power flow control-Constraints of maximum transmission line loading-Basic types of FACTS controllers-Benefits of FACTS transmission line compensation-Uncompensated line-Shunt and series compensation principles.

UNIT II	**STATIC SHUNT COMPENSATORS**	**9**	**0**	**0**	**9**

Static versus passive VAR compensator-Static shunt compensators: SVC and STATCOM-Operation and control of TSC, TCR and STATCOM-Compensator control-Comparison between SVC and STATCOM.

UNIT III	**STATIC SERIES COMPENSATOR**	**9**	**0**	**0**	**9**

Static voltage and Phase angle regulators-TCVR and TCPAR operation and control-Applications-Static series compensation: GCSC, TSSC, TCSC and Static synchronous series compensators and their control.

UNIT IV	**COMBINED AND SPECIAL PURPOSE FACTS CONTROLLERS**	**9**	**0**	**0**	**9**

SSR and its damping-Unified Power Flow Controller: Circuit arrangement, operation and control of UPFC-Basic principle of P and Q control-Independent real and reactive power flow control-Applications- Interline Power Flow Controller (IPFC): Basic operation, structure and applications.

UNIT V	**COORDINATION OF FACTS CONTROLLERS**	**9**	**0**	**0**	**9**

Controller interactions - SVC-SVC interaction - SVC-HVDC interaction – SVC -TCSC interaction - TCSC-TCSC interaction - Coordination of multiple controllers using linear control techniques - Non-linear control techniques – Emerging FACTS Controllers: The STATCOM - The SSSC - The UPFC - Comparative evaluation of different FACTS controllers.

Total (45L+0T)= 45 Periods

References:

1.	N.G. Hingorani, L. Gyugyi, “Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems”, IEEE Press Book, Standard Publishers and Distributors, Delhi, 2001.
2.	K.R. Padiyar, “FACTS Controllers in Power Transmission and Distribution”, New Age International Publishers, 2007.
3.	Arindam Ghosh, Gerard Ledwich, “Power Quality Enhancement using Custom Power Devices”, Springer Science, 2002.
4.	X.P. Zhang, C. Rehtanz, B. Pal, “Flexible AC Transmission Systems- Modelling and Control”, Springer Verlag, Berlin, 2006.
5.	R. Mohan Mathur, Rajiv K Verma, “Thyrisor-Based FACTS Controllers for Electrical Transmission Systems”, IEEE press, Wiley-Interscience Publications, 2002.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Recall reactive power flow control in power systems.	L1: Remembering
CO2	:	Discuss various static series and shunt compensation techniques.	L2: Understanding
CO3	:	Analyze the structure and principle of operation of FACTS devices.	L4: Analyzing
CO4	:	Apply the FACTS devices at suitable location in power system networks.	L3: Applying
CO5	:	Construct the co-ordination of FACTS controllers.	L4: Analyzing

COURSE ARTICULATION MATRIX														
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	2	3	1	1	1	1	3	1	2	1	1	3	3	1
CO2	2	1	3	3	1	1	3	1	1	2	1	1	2	2
CO3	1	1	2	2	2	3	1	1	1	3	1	2	2	2
CO4	2	3	2	3	3	1	2	2	1	2	2	2	3	1
CO5	2	1	3	2	1	1	2	3	1	2	1	2	2	1
Avg	1.80	1.80	2.20	2.20	1.60	1.40	2.20	1.60	1.20	2.00	1.20	2.00	2.40	1.40
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)														

22PEE54	HVDC TRANSMISSION SYSTEMS				SEMESTER III	
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Power Systems		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To understand the concept, planning of DC power transmission and comparison with AC power transmission.
2.	To analyze HVDC converters.
3.	To study about the HVDC system control.
4.	To design harmonics filters.
5.	To impart knowledge on simulation of HVDC systems.

UNIT I	**DEVELOPMENT OF HVDC TECHNOLOGY**	**9**	**0**	**0**	**9**
Introduction – Comparison of AC and DC transmission – Applications of DC transmission – HVDC system configurations and components – Planning for HVDC transmission – Modern trends in DC transmission. MTDC systems: Potential applications, Types – control and protection – study of MTDC System.					
UNIT II	**ANALYSIS OF HVDC CONVERTERS**	**9**	**0**	**0**	**9**
Pulse number – Choice of best topology for HVDC – Analysis of six pulse bridge converter without overlap, and with overlap less than 60˚ - Equivalent circuit model - Abnormal operation: Arcback, Commutation failure, Arcthrough, Misfire - Converter bridge characteristics - Multiple bridge converters.					
UNIT III	**CONTROL OF HVDC SYSTEMS**	**9**	**0**	**0**	**9**
Basic principles of control – Desired features of control – Limitations of manual control -Control implementation: Hierarchy of different levels of HVDC system controls – Converter firing control schemes – Valve blocking and bypassing – Starting, stopping and power flow reversal – Controls for enhancement of AC system performance – Higher level controllers -Fault development and protection-Functions of smoothing reactors.					
UNIT IV	**REACTIVE POWER CONTROL, HARMONICS AND FILTERS**	**9**	**0**	**0**	**9**
Reactive Power requirements in steady state – sources of reactive power – static VAR systems. Introduction – Characteristic harmonics – noncharacteristic harmonics – Troubles caused by harmonics – Definitions of wave distortion or ripple – Means of reducing harmonics – Telephone interference – Design of minimum cost tuned AC filters – DC side harmonics.					
UNIT V	**SIMULATION OF HVDC SYSTEMS**	**9**	**0**	**0**	**9**
Modelling of HVDC systems, per unit system, Representation for power flow solution, representation for stability studies. System simulation: Philosophy and tools – HVDC system simulation – Modelling of HVDC systems for digital dynamic simulation					
					Total (45L+0T)= 45 Periods

References:

1.	Padiyar, K.R., "HVDC Power Transmission Systems", New Age International Publishers, New Delhi, 2010.
2.	Arrillaga, J., "HVDC Transmission", Peter Peregrinus, London, 1983.
3.	Colin Adamson and N.G.Hingorani, "High Voltage Direct current Power Transmission", Garraway Limited, London, First edition, 1960.
4.	Edward Wilson Kimbark, "Direct Current Transmission", Vol.I, Wiley Interscience, New York, 1971.
5.	Erich Uhlmann, "Power Transmission by Direct Current", B.S. Publications, 2004.
6.	Kamakshaiah, S. & Kamaraju, V, "HVDC Transmission", 1st Edition, Tata McGraw Hill, 2011.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Outline the concept of HVDC technology	L1: Remembering
CO2	:	Explain the basic concepts of HVDC and MTDC systems.	L2: Understanding
CO3	:	Analyze and control six-pulse and multiple-bridge converters	L4: Analyzing
CO4	:	Design harmonics filters.	L4: Analyzing
CO5	:	Develop the modelling of HVDC systems	L2: Understanding
CO6	:	Apply simulation tools for HVDC system	L3: Applying

COURSE ARTICULATION MATRIX														
COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO1 0**	**PO1 1**	**PSO 1**	**PSO2**	**PSO3**
CO1	3	1	2	3	2	1				2	1	3	3	1
CO2	3	2	3	3	1	1	1	1	1	2	1	1	2	2
CO3	3	2	3	1	1					1		2	2	2
CO4	2	2	3	3	2	1	1	1	1	2	1	2	3	1
CO5	2	3	2	2	1	1	2	1	1	1	1	2	2	1
CO6	1	2	2	3	3	1	2	1	1	2	2	2	2	1
Avg	2.33	2.00	2.50	2.50	1.67	0.83	1.5	1	1	1.67	1.00	2.00	2.33	1.33
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)														

22PEE55	SCADA SYSTEMS AND APPLICATIONS			SEMESTER III			
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**	
		Hours/Week	**L**	**T**	**P**	**TH**	
			3	**0**	**0**	**3**	

Course Objectives:

1. To understand the SCADA system components, communication protocols and its application to power system.

		L	T	P	TH
UNIT I	**INTRODUCTION TO SCADA**	**9**	**0**	**0**	**9**

Evolution of SCADA, SCADA definitions, SCADA Functional requirements and Components, SCADA Hierarchical concept, SCADA architecture, General features, SCADA Applications, Benefits.

		L	T	P	TH
UNIT II	**SCADA SYSTEM COMPONENTS**	**9**	**0**	**0**	**9**

Remote Terminal Unit (RTU), Interface units, Human- Machine Interface Units (HMI), Display 55 Monitors/Data Logger Systems, Intelligent Electronic Devices (IED), Communication Network, SCADA Server, SCADA Control systems and Control panels.

		L	T	P	TH
UNIT III	**SCADA COMMUNICATION**	**9**	**0**	**0**	**9**

SCADA Communication requirements, Communication protocols: Past, Present and Future, Structure of a SCADA Communications Protocol, Comparison of various communication protocols, IEC61850 based communication architecture, Communication media like Fiber optic, PLCC etc. Interface provisions and communication extensions, synchronization with NCC, DCC.

		L	T	P	TH
UNIT IV	**MONITORING AND CONTROL**	**9**	**0**	**0**	**9**

SCADA: Online monitoring the event and alarm system, trends and reports, Blocking list, Event disturbance recording. Control function: Station control, bay control, breaker control and disconnector control.

Wide area Monitoring Systems (WAMS), Phasor Measurement Unit (PMU), A generic PMU - The global positioning system - Hierarchy for phasor measurement systems – Functional requirements, PMU placement.

		L	T	P	TH
UNIT V	**SCADA APPLICATIONS**	**9**	**0**	**0**	**9**

Applications in Generation, Transmission and Distribution sector, Substation SCADA system Functional description, System specification, System selection such as Substation configuration, IEC61850 ring configuration, SAS cubicle concepts, gateway interoperability list, signal naming concept. System Installation, Testing and Commissioning.

CASE STUDIES: SCADA Design for 66/11KV and 132/66/11KV or 132/66 KV any utility Substation and IEC 61850 based SCADA Implementation issues in utility Substations.

Total (45 L+ 0 T) = 45 Periods

References:

1. Stuart A. Boyer, “SCADA-Supervisory Control and Data Acquisition”, Instrument Society of America Publications, USA, 2010.
2. Gordon Clarke, and Deon Reynders, “Practical Modern SCADA Protocols: DNP3, 60870.5 and Related Systems”, Newnes Publications, Oxford, UK, 2004.
3. William T. Shaw, “Cybersecurity for SCADA Systems”, PennWell Books, 2021.
4. David Bailey and Edwin Wright, “Practical SCADA for Industry”, Newnes, 2003.
5. Phadke, A.G., and Thorp, J.S., “Synchronized Phasor Measurements and Their Applications”, Springer, 2008.
6. Michael Wiebe, “A Guide to Utility Automation: AMR, SCADA, and IT Systems for Electric Power”, PennWell. 1999.
7. Dieter K. Hammer, Lonnie R. Welch, and Dieter K. Hammer, “Engineering of Distributed Control Systems”, Nova Science Publishers, USA, 1998.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Identify the basic tasks of Supervisory Control Systems (SCADA) as well as their typical applications**.**	L2: Understanding
CO2	:	Recognize SCADA architecture, various advantages and disadvantages of each system.	L2: Understanding
CO3	:	Interpret single unified standard architecture IEC 61850.	L3: Applying
CO4	:	Demonstrate SCADA system components: remote terminal units, PLCs, intelligent electronic devices, HMI systems.	L3: Applying
CO5	:	Use SCADA in electric power transmission and distribution sector, industries etc.	L3: Applying

COURSE ARTICULATION MATRIX

COs\POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO 1	2	2	2	1	1		3	1		1	3	2	3	1
CO 2	2	2	3	3	1		3	1		2	3	2	2	1
CO 3	2	2	2	2	2		1	1		3	3	2	3	1
CO 4	2	3	2	3	3		2	2		2	2	2	2	1
CO 5	2	2	3	3	3		2	3		2	2	2	2	1
Avg	2	2.2	2.4	2.4	2		2.2	1.6		2	2.6	2	2.4	1

3/ 2/ 1 – indicates strength of correlation (3- High, 2-Medium, 1-Low)

22PEE61	ELECTRICAL VEHICLES AND POWER MANAGEMENT					SEMESTER III	
PREREQUISTIES		**CATEGORY**	**PE**	**Credit**		**3**	
		Hours/Week	**L**	**T**	**P**	**TH**	
			3	**0**	**0**	**3**	

Course Objectives:

1.	To provide knowledge on electric vehicle architecture and its charging infrastructure
2.	To impart knowledge on power electronic interface for vehicle control and electric propulsion system

UNIT I	**ELECTRIC VEHICLE**	**9**	**0**	**0**	**9**

Configurations of Electric Vehicles (EV), Performance of Electric Vehicles, Tractive Effort in Normal Driving and Energy Consumption, Hybrid Electric Vehicles (HEV): Classification, Series Hybrid Electric Drive Trains, Parallel Hybrid Electric Drive Trains

UNIT II	**PLUG-IN HYBRID ELECTRIC VEHICLE (PHEV) AND FUEL CELL ELECTRIC VEHICLE**	**9**	**0**	**0**	**9**

Functions and Benefits of PHEV, Components of PHEVs, Operating Principle of Plug-in Hybrid Vehicle, Control Strategy of PHEV, Fuel Cell: Operation and Types, Fuel Cell Electric Vehicle: Configuration and Control Strategy

UNIT III	**ELECTRIC PROPULSION SYSTEM**	**9**	**0**	**0**	**9**

Typical electric propulsion system, Classification of electric motor drives for EV and HEV, Multiquadrant Control of Chopper-Fed DC Motor Drives, Vector Control of Induction Motor drives, Permanent Magnetic Brush-Less DC Motor Drives, Switched Reluctance Motor Drives for Electric Vehicles

UNIT IV	**POWER ELECTRONICS FOR ELECTRIC VEHICLE CHARGERS**	**9**	**0**	**0**	**9**

Charger Classification and Standards, Power Converter Topologies for Level 1 and 2 AC Chargers, Front-End AC–DC Converter Topologies, Power Converter Topology Selection for Level 3 Chargers, Wireless Chargers: Inductive Charging and Resonant Inductive Charging

UNIT V	**EV AND PHEV CHARGING INFRASTRUCTURE**	**9**	**0**	**0**	**9**

EV/PHEV Batteries and Charging Regimes: Battery Parameters and Characteristics, EV Battery Charging Methods, Termination Methods, Cell Balancing, SOC Estimation, Charging Algorithms, Power Electronics for EV and PHEV Charging Infrastructure: Charging Hardware and Grid-Tied Infrastructure

Total (45L+0T)= 45 Periods

References:

1.	Iqbal Hussain, “Electric and Hybrid Vehicles: Design Fundamentals”,CRC Press, Taylor & Francis Group, Second Edition, 2011.
2.	Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, AliEmadi,, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles CRC Press, 2016
3.	Ali Emadi, Mehrdad Ehsani, John M.Miller ,“Vehicular Electric Power Systems”, Special Indian Edition, Marcel dekker, Inc 2010
4.	https://archive.nptel.ac.in/courses/108/103/108103009

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Level**
CO1	:	Explain the fundamentals of electric vehicle and its mechanics	L2-Understanding
CO2	:	Describe the architecture of electric and hybrid electric vehicle.	L1-Remembering
CO3	:	Analyze the four quadrant operation of DC drive, induction motor drive and SRM drive Electric vehicle	L4-Analyzing
CO4	:	Select a suitable power converter for Electric Vehicle	L4-Analyzing
CO5	:	Illustrate the charging infrastructure and algorithm for Electric vehicle and Plug-in Hybrid Electric Vehicle	L3-Applying

COURSE ARTICULATION MATRIX														
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	1		1	3	1	2	1		1	2	1	2	1	1
CO2	1	2	3	1		1	2	1	1		1	2	2	
CO3	1	1			2		3	2	1	2	1	3	1	1
CO4	3	1	2	1	2	1	1				3	2	1	
CO5	1	2	1	2	1	2		1	2	1		3	2	1
Avg	1.40	1.50	1.75	1.75	1.50	1.50	1.75	1.33	1.25	1.67	1.50	2.40	1.40	1.00
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)														

22PEE62	GRID INTEGRATION OF RENEWABLE ENERGY SOURCES			SEMESTER III		
PREREQUISTIES		**CATEGORY**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To introduce the concepts of Solar and Wind energy conversion system
2.	To familiarize the power electronic interface for Solar and Wind energy conversion system
3.	To study high power converter topologies for grid integration of renewable energy sources

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**
Different Types of Grid Interfaces, Issues Related to Grid Integration of Small Scale Generation: Protection Issues, Voltage Control, Harmonics Control, Grid Integration of Large Scale Renewable Energy Generation, Interconnection Standards and Grid Codes					
UNIT II	**GRID INTEGRATION OF WIND ENERGY SYSTEMS**	**9**	**0**	**0**	**9**
Wind Power Conversion Configuration, Fixed speed wind turbine with direct grid connection using a soft starter, Partial-scale variable speed wind turbine with variable rotor resistance, Variable speed wind turbine with full-scale power converter, Requirements of modern wind power converters, Controls and Grid Requirements for Modern Wind Turbines: Active Power Control, Reactive Power Control, Total Harmonic Distortion, Fault Ride-Through Capability					
UNIT III	**PHOTOVOLTAIC ENERGY CONVERSION SYSTEMS**	**9**	**0**	**0**	**9**
Generic grid-connected PV energy conversion system, Grid-connected PV system configurations, Utility-scale PV plant based on central inverter configuration, Multilevel central inverter PV systems, Variants of the transformer less H-bridge string inverter for grid integration, multi-string PV grid configurations, AC-module PV system based on resonant H-bridge HF DC–DC converter and H-bridge inverter					
UNIT IV	**CONTROL OF GRID-CONNECTED PV SYSTEMS**	**9**	**0**	**0**	**9**
Maximum Power Point Tracking Control Methods, DC–DC Stage Converter Control, Grid-Tied Converter Control: Voltage-oriented control for single phase and three-phase grid-tied PV inverters, Anti-islanding Detection, Three-phase NPC and CHB multi-string topology for multi-megawatt PV application					
UNIT V	**CONTROLLABILITY ANALYSIS OF GRID TIED RENEWABLE ENERGY SYSTEMS**	**9**	**0**	**0**	**9**
Controllability of Wind Turbine Connected through L Filter to the Grid, Controllability of Wind Turbine Connected through LCL Filter to the Grid, Controllability and Stability Analysis of PV System Connected to Current Source Inverter					
					Total (45L+0T)= 45 Periods

References:

1.	Haitham Abu-Rub, Mariusz Malinowski, Kamal Al-Haddad, Power electronics for renewable energy systems, transportation, and industrial applications, John Wiley & Sons Ltd, 2014
2.	S. Sumathi, L. Ashok Kumar, P. Surekha, Solar PV and Wind Energy Conversion Systems Springer International Publishing AG Switzerland, 2015

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Level**
CO1	:	Recall the principle of Solar and Wind energy conversion system	L1-Remembering
CO2	:	Summarize the requirements of control for Wind energy conversion system	L2-Understanding
CO3	:	Identify the suitable system configuration for Solar PV system	L1-Remembering
CO4	:	Select a high power converter topology for renewable energy source grid integration	L4-Analyzing
CO5	:	Analyze the controllability of grid tied renewable energy system	L4-Analyzing

COURSE ARTICULATION MATRIX													
COs/ POs	**PO1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	2	1	2	3		1	3	2	2	1	1	1	1	1
CO2	1	2	1		2	1			1	3		1	2	2
CO3	2	1	2	2	1	3	2	1		2	2	3	1	1
CO4	3		3		2		3		2	1		2	1	
CO5	1	3		2		1	1	1			2	3	2	1
Avg	2.00	1.33	2.00	2.50	1.67	1.67	2.67	1.50	1.67	1.75	1.50	1.75	1.25	1.33

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

22PEE63	ENERGY STORAGE TECHNOLOGISES					SEMESTER III	
PREREQUISTIES		CATEGORY	PE	Credit		3	
		Hours/Week	L	T	P	TH	
			3	0	0	3	

Course Objectives:

1. To explore the fundamentals, technologies and applications of energy storage

UNIT I	STORAGE: HISTORICAL PERSPECTIVE, INTRODUCTION AND CHANGES	9	0	0	9

Storage Needs- Variations in Energy Demand- Variations in Energy Supply- Interruptions in Energy Supply- Transmission Congestion - Demand for Portable Energy-Demand and scale requirements - Environmental and sustainability issues

UNIT II	TECHNICAL METHODS OF STORAGE	9	0	0	9

Static and rotating reference frames – Stationary circuit variables transformed to the arbitrary reference frame – Commonly used reference frame -Transformation of variables – Transformation between reference frames – Transformation of a balanced set – Balanced steady state phasor and voltage equations – Variables observed from several frames of reference.

UNIT III	PERFORMANCE FACTORS OF ENERGY STORAGE SYSTEMS	9	0	0	9

Energy capture rate and efficiency- Discharge rate and efficiency- Dispatch ability and load flowing characteristics, scale flexibility, durability – Cycle lifetime, mass and safety – Risks of fire, explosion, toxicity- Ease of materials, recycling and recovery- Environmental consideration and recycling , Merits and demerits of different types of Storage.

UNIT IV	APPLICATION CONSIDERATION	9	0	0	9

Comparing Storage Technologies- Technology options- Performance factors and metrics- Efficiency of Energy Systems- Energy Recovery - Battery Storage System: Introduction with focus on Lead Acid and Lithium- Chemistry of Battery Operation, Power storage calculations, Reversible reactions, Charging patterns, Battery Management systems, System Performance, Areas of Application of Energy Storage: Waste heat recovery, Solar energy storage, Green house heating, Power plant applications, Drying and heating for process industries, energy storage in automotive applications in hybrid and electric vehicles

UNIT V	HYDROGEN FUEL CELLS AND FLOW BATTERIES	9	0	0	9

capacitors: properties, power calculations – Operation and Design methods - Hybrid Energy Storage: Managing peak an Continuous power needs, options - Level 1: (Hybrid Power generation) Bacitor "Battery + Capacitor" Combinations: nee operation and Merits; Level 2: (Hybrid Power Generation) Bacitor + Fuel Cell or Flow Battery operation-Applications: Storag for Hybrid Electric Vehicles,Regenerative Power, capturing methods.

Total (45L+0T)= 45 Periods

References:

1.	DetlefStolten,"Hydrogen and Fuel Cells: Fundamentals, Technologies and Applications", Wiley, 2010.
2.	Jiujun Zhang, Lei Zhang,Hansan Liu, Andy Sun, Ru-Shi Liu, "Electrochemical Technologies for Energy Storage and Conversion", John Wiley and Sons, 2012.
3.	Francois Beguin and ElzbietaFrackowiak ,"Super capacitors", Wiley, 2013.
4.	Doughty Liaw, Narayan and Srinivasan, "Batteries for Renewable Energy Storage", The

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Recollect the historical perspective and technical methods of energy storage.	L1: Remembering
CO2	:	Learn the basics of different storage methods.	L:2 Understanding
CO3	:	Understand the concepts of energy conversion technology	L2: Understanding
CO4	:	Determine the performance factors of energy storage systems	L5: Evaluating
CO5	:	Identify the applications of various energy storage systems	L3: Applying

COURSE ARTICULATION MATRIX													
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	2	2	2	2	2	1	2	1	3	2	1	3	2
CO2	3	2	2	2	2	2	1	2	1	2	1	1	1	2
CO3	3	3	3	3	2	2	1	2	1	2	1	2	2	1
CO4	3	3	3	3	2	2	1	2	1	2	1	2	1	2
CO5	3	3	3	3	2	2	1	2	1	2	1	1	2	1
Avg	3	2.6	2.6	2.6	2	2	1	2	1	2.2	1.2	1.4	1.8	1.6
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)														

22PEE64	INTERNET OF THINGS FOR SMART SYSTEM					SEMESTER III	
PREREQUISTIES		**CATEGORY**		**PE**	**Credit**		**3**
		Hours/Week		**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:

1.	To illustrate the concept of Internet of Things (IoT) and devices for physical world interface.
2.	To familiarize with communication technologies and cloud computing platform for IoT system
3.	To study the development of IoT system for electrical engineering applications.

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Internet of Things - Definition- IoT conceptual framework-IoT architecture and Features, Major Components of IoT System, IoT software components for device hardware, Development Tools for IoT,

UNIT II	**IOT DEVICES**	**9**	**0**	**0**	**9**

Sensors: Sensing the Real World, Analog Sensors and Digital Sensors, Sensors for Temperature, Humidity, Distance, Light, Acceleration, Vibrations and Shocks, Orientation and Direction Compass, Magnetic Sensors/Magnetometer, Sound, Sensing the Things: Reading Barcodes, QR Code, Motion Sensors for Moving Objects, Environmental Monitoring Sensor, GPS, Actuators: Piezoelectric vibrators and sounders, Speakers, Solenoids, Servomotor, Relay switch

UNIT III	**IOT COMMUNICATION AND PROTOCOLS**	**9**	**0**	**0**	**9**

M2M Communication for IoT, M2M Architecture, M2M Software and Development Tools, Modified OSI Model for the IoT/M2M Systems, Near-Field Communication, RFID, Bluetooth BR/EDR and Bluetooth Low Energy, ZigBee, Wi-Fi, GPRS/GSM Cellular Networks-Mobile Internet, Differences between NFC, BT LE, ZigBee and WLAN protocols, Sensor data communication Protocols: LIN Serial Bus, CAN Protocol for Serial Bus,

UNIT IV	**IOT CLOUD COMPUTING**	**9**	**0**	**0**	**9**

Cloud computing paradigm for data collection, storage and Computing, Cloud Computing Features and Advantages, Cloud Deployment Models, PaaS, SaaS, IaaS and DaaS Cloud Service models, IoT cloud-based services, Public Cloud IoT Platforms

UNIT V	**IOT FOR SMART SYSTEM**	**9**	**0**	**0**	**9**

IoT based Advanced Metering Infrastructure, Advanced Metering Infrastructure: Smart Devices, Communication, Data Management System, Mathematical Modeling, Energy Theft Detection Techniques and Intrusion Detection System, Automotive IoT: Connected Cars Technology, Vehicle-to-Infrastructure Technology and Predictive and Preventive Maintenances

Total (45L+0T)= 45 Periods

References:

1.	Pethuru Raj & Anupama C Mohan, The Internet of Things – Enabling Technologies, Platforms, and Use Cases,CRCPress, 2017.
2.	Raj Kamal ,Internet of Things Architecture and Design Principles, McGraw Hill Education (India) Private Limited, 2017
3.	Olivier Hersent, David Boswarthick & Omar Elloumi, The Internet of Things – Key applications and Protocols, John Wiley, 2012.
4.	https://archive.nptel.ac.in/courses/106/105/106105166/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Level**
CO1	:	Explain the structure and components of IOT system.	L2-Understanding
CO2	:	Select an appropriate device to interface IOT system with physical world	L4-Analyzing
CO3	:	Identify and use the communication technologies for IOT system	L3-Applying
CO4	:	Use a cloud computing platform for an IoT application	L3-Applying
CO5	:	Illustrate the IOT smart system for real time electrical engineering	L4-Analyzing

COURSE ARTICULATION MATRIX														
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	1		1	3	1	2	1		1	2	1		2	1
CO2	2	2	3	1		1	2	2		1	1	1	1	2
CO3	1	3	2		2		3	2	3	2	1	1	2	1
CO4	2	1	2	1	1	1	1				2	1	2	1
CO5	1	3		2	1	2		1	2	1		3	2	1
Avg	1.40	2.25	2.00	1.75	1.25	1.50	1.75	1.67	2.00	1.50	1.25	1.50	1.80	1.20
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)														

22PEE65	DIGITAL SIGNAL PROCESSORS FOR POWER CONVERTERS			SEMESTER III			
PREREQUISITES			**CATEGORY**	**PE**	**Credit**		**3**
Microcontroller , Power Electronics			**Hours/Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**
Course Objectives:							
To understand the basic concepts of TMS320F28379D DSP Architecture for Power Control, CLA and IPC for Dual Core Processors and its applications to power converters.							
UNIT I	**TMS320F28379D DSP ARCHITECTURE FOR POWER CONTROL**			**9**	**0**	**0**	**9**
Overview of C28x DSP - Architecture Overview of TMS320F28379D- C28x family: CPU system control - FPU and CLA - Memory Architecture - Dedicated Memory - Global Shared memory - Local shared memory - Message passing Memory - Math Accelerator - VCU - TMU - Fast Interrupt response manager - Code Security manager.							
UNIT II	**ANALOG SYSTEMS**			**9**	**0**	**0**	**9**
ADC - Triggerring and conversion sequencing - ADC SOC functional diagram and operation - Examples for ADC implementation - Comparator sub system - Functional diagram and operation - Examples for implementation - DAC - functional diagram and application.							
UNIT III	**CONTROL PERIPHERALS**			**9**	**0**	**0**	**9**
ePWM - ePWM signals and connections - ePWM block diagram - study of individual sub-moduled of ePWM - Typical application configurations of ePWM for dc-dc converter and inverters - HRPWM - eCAP - modes of operations - eQEP - functional block diagram and connections.							
UNIT IV	**CLA AND IPC FOR DUAL CORE PROCESSORS**			**9**	**0**	**0**	**9**
CLA - purpose and operation - CLA overview and functional block diagram - operation - CLA memory and register access - CLA Tasks - IPC features - Messaging with flags and interrupts - IPC data transfer.							
UNIT V	**APPLICATIONS TO POWER CONVERTERS**			**9**	**0**	**0**	**9**
Configuring and closed loop control for BUCK and Boost converters - Configuring and closed loop control for single phase inverter - Configuring and closed loop control for three phase inverters - Configuring and closed loop control for different Electric Motors							
							Total (45L+0T) = 45 Periods

References:	
1.	Texas 320F28379D Manuals
2.	Texas 320F28379D Datasheet
3.	Texas 320F28379D Microcontroller Workshop Manual
4.	C2000 Delfino Workshop Manual
5.	C2000 CLA Software Development Guide

Course Outcomes:			
Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the basic concepts of TMS320F28379D DSP Architecture for Power Control	L2:Understanding
CO2	:	Appreciate the importance of analog systems and implementation.	L1:Remembering
CO3	:	Understand the concepts of ePWM and eQEP	L2:Understanding
CO4	:	Understand the usage of CLA and IPC for Dual Core Processors	L4:Analyzing
CO5	:	Able to realize the controller designed in the suitable form for Power Converter applications.	L6:Creating

COURSE ARTICULATION MATRIX														
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	1		2	3	3					1			3	1
CO2	1		2	3	2					1		2	2	1
CO3	1	2	3	3	2					1		3	3	1
CO4	1		2	3	3					1	1		3	1
CO5	1	2	2	3	2		1	2	1	1	1	2	2	1
Avg	1	2	2.2	3	2.4	0	1	2	1	1	1	2.3	2.6	1
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)														

22AC01	ENGLISH FOR RESEARCH PAPER WRITING			SEMESTER I & II			
PREREQUISTIES		**CATEGORY**		**AC**	**Credit**		**0**
Basic skill in paper writing on a particular topic		**Hours/Week**		**L**	**T**	**P**	**TH**
				2	**0**	**0**	**2**

COURSE OBJECTIVES

1.	To help the learners to realize the necessity of English in writing a Research paper
2.	To enable the learners to write different sections of a research paper
3.	To train the learners to become better writers of research papers

UNIT I	**6**	**0**	**0**	**0**
Research paper and its importance, Structure of a research paper, Planning and preparation.				
UNIT II	**6**	**0**	**0**	**0**
English in research papers, Basic word order, Collocation, Being concise, Redundancy, Common errors.				
UNIT III	**6**	**0**	**0**	**0**
Key factors that determine the style of a paper, Journal's background, Passive form, Right tense forms, Cohesion and coherence.				
UNIT IV	**6**	**0**	**0**	**0**
Hedging and criticizing, Paraphrasing, Plagiarism, Ensuring quality of the paper and Useful phrases.				
UNIT V	**6**	**0**	**0**	**0**
Key skills in writing Title, Abstract, Introduction, Review of Literature, Discussion and Conclusion, Highlighting findings.				
Total (30L+0T) = 30 Periods				

REFERENCE BOOKS:

1.	Adrian Wallwork, "English for Writing Research Papers," Springer New York Dorecht Heidelberg London, 2016
2.	Howe, Stephen. "Phrase Book for Writing papers and Research in English," Cambridge University Press, 2012.
3.	Goldbort R. "Writing for Science," Yale University press, 2006.
4	Gabor L Lovei. "Writing and Publishing Scientific Paper," Open Book Publishers, 2021

COURSE OUTCOMES: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	understand and appreciate the role of English in writing a good research paper	L2: Understanding
CO2	:	apply their knowledge in writing a research paper	L3: Applying
CO3	:	analyze and assess the quality of their research paper	L4: Analyzing

COURSE ARTICULATION MATRIX

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	0	2	0	0	0	0	2	3	0	1	0	0	0	1
CO2	0	3	0	0	0	0	1	3	0	1	0	0	0	2
CO3	0	2	0	0	0	0	1	3	0	1	0	0	0	1
Avg	0	2.3	0	0	0	0	1.3	3	0	1	0	0	0	1.3

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

22AC02	DISASTER MANAGEMENT			SEMESTER I / II			
PREREQUISITE			**CATEGORY**	**AC**	**Credit**		**0**
			Hours/Week	**L**	**T**	**P**	**TH**
				2	**0**	**0**	**2**

Course Objectives:

To have a critical understanding of key concepts in disaster risk reduction and humanitarian response policy and practice from multiple perspectives. Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations and evaluate the strengths and weaknesses of disaster management approaches. Planning and programming in different countries, particularly their home country or the countries they work in.

UNIT I	**INTRODUCTION - DISASTER PRONE AREAS IN INDIA**	**4**	**0**	**0**	**0**
Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude. Disaster Prone Areas In India : Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post Disaster Diseases And Epidemics					
UNIT II	**REPERCUSSIONS OF DISASTERS AND HAZARDS**	**4**	**0**	**0**	**0**
Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.					
UNIT III	**DISASTER PREPAREDNESS AND MANAGEMENT**	**4**	**0**	**0**	**0**
Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness.					
UNIT IV	**RISK ASSESSMENT**	**4**	**0**	**0**	**0**
Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People’s Participation In Risk Assessment. Strategies for Survival.					
UNIT V	**DISASTER MITIGATION**	**4**	**0**	**0**	**0**
Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India.					
					Total (20L+0T)= 20 Periods

REFERENCES:

1.	R. Nishith, Singh AK, “Disaster Management in India: Perspectives, issues and strategies “’New Royal book Company.
2.	Sahni, PardeepEt.Al. (Eds.),” Disaster Mitigation Experiences And Reflections”, Prentice Hall Of India, New Delhi.

COURSE OUTCOMES

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

CO1	**:**	Learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
CO2	**:**	Critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives
CO3	**:**	Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations
CO4	**:**	Critically understand the strengths and weaknesses of disaster management approaches

COURSE ARTICULATION MATRIX														
COs / POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1					1	1	1	1	1	1	1			
CO2					1	1	1	1	1	1	1			
CO3					1	1	1	1	1	1	1			
CO4					1	1	1	1	1	1	1			
Avg					1	1	1	1	1	1	1			
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)														

22AC03	SANSKRIT FOR TECHNICAL KNOWLEDGE			SEMESTER I / II			
PREREQUISITE		CATEGORY		AC	Credit		0
		Hours/Week		L	T	P	TH
				2	0	0	2

Course Objectives:

To get a working knowledge in illustrious Sanskrit, the scientific language in the world. Learning of Sanskrit to improve brain functioning. Learning of Sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power. The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature.

Unit I		8	0	0	0

Alphabets in Sanskrit-Past/Present/Future Tense-Simple Sentences

Unit II		8	0	0	0

Order-Introduction of roots-Technical information about Sanskrit Literature

Unit III		8	0	0	0

Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics

Total (24L+0T)= 24 Periods

REFERENCE BOOKS:

1.	Abhyaspustakam" – Dr.Vishwas, Samskrita-Bharti Publication, New Delhi
2.	"Teach Yourself Sanskrit" PrathamaDeeksha-VempatiKutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3.	India‟s Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi

COURSE OUTCOMES

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

CO1	:	Understanding basic Sanskrit language
CO2	**:**	Ancient Sanskrit literature about science & technology can be understood
CO3	**:**	Being a logical language will help to develop logic in students

COURSE ARTICULATION MATRIX

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1					1	1	1	1	1	1	1			
CO2					1	1	1	1	1	1	1			
CO3					1	1	1	1	1	1	1			
Avg					1	1	1	1	1	1	1			

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

22AC04	VALUE EDUCATION				SEMESTER I / II		
PREREQUISITE			**CATEGORY**	**AC**	**Credit**		**0**
			Hours/Week	**L**	**T**	**P**	**TH**
				2	**0**	**0**	**2**

Course Objectives:

To understand the importance of value education and self-development. To imbibe good values in students and also know about the importance of character.

Unit I	**4**	**0**	**0**	**0**

Values and self-development – Social values and individual attitudes - Work ethics, Indian vision of Humanism Moral and non-moral valuation - Standards and principles - Value judgements.

Unit II	**6**	**0**	**0**	**0**

Importance of cultivation of values - Sense of duty-Devotion - Self-reliance – Confidence – Concentration – Truthfulness – Cleanliness – Honesty – Humanity -Power of faith - National Unity – Patriotism - Love for nature – Discipline

Unit III	**6**	**0**	**0**	**0**

Personality and Behavior Development - Soul and Scientific attitude – Positive – Thinking - Integrity and discipline-Punctuality - Love and Kindness - Avoid fault Thinking - Free from anger - Dignity of labor - Universal brotherhood and religious tolerance - True friendship-Happiness Vs suffering - love for truth - Aware of selfdestructive habits-Association and Cooperation - Doing best for saving nature

Unit IV	**6**	**0**	**0**	**0**

Character and Competence – Holy books vs Blind faith - Self-management and Good health -Science of reincarnation-Equality – Nonviolence – Humility - Role of Women - All religions and same message - Mind your Mind - Self-control – Honesty - Studying effectively

Total (22L+0T)= 22 Periods

Course Outcomes

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

CO1	:	Knowledge of self-development
CO2	:	Critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives
CO3	:	Learn the importance of Human values
CO4	:	Developing the overall personality

Suggested Reading:

1. Chakraborty, S.K. “Values and Ethics for organizations Theory and practice”, Oxford University Press, New Delhi,1998.

COURSE ARTICULATION MATRIX

COs / POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1					1	1	1	1	1	1	1			
CO2					1	1	1	1	1	1	1			
CO3					1	1	1	1	1	1	1			
CO4					1	1	1	1	1	1	1			
Avg					1	1	1	1	1	1	1			

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

22AC05	CONSTITUTION OF INDIA			SEMESTER I / II			
PREREQUISITE		CATEGORY		AC	Credit		0
		Hours/Week		L	T	P	TH
				2	0	0	2

COURSE OBJECTIVES:

Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective. To address the growth of Indian opinion regarding modern Indian intellectuals" constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.

Unit	Title	L	T	P	TH
Unit I	**HISTORY OF MAKING OF THE INDIAN CONSTITUTION**	**4**	**0**	**0**	**0**
History, Drafting Committee, (Composition & Working)					
Unit II	**PHILOSOPHY OF THE INDIAN CONSTITUTION**	**4**	**0**	**0**	**0**
Preamble, Salient Features					
Unit III	**CONTOURS OF CONSTITUTIONAL RIGHTS & DUTIES**	**4**	**0**	**0**	**0**
Fundamental rights, right to equality, right to freedom, right against exploitation, right to freedom of religion, cultural and educational rights, right to constitutional remedies, directive principles of state policy, fundamental duties					
Unit IV	**ORGANS OF GOVERNANCE**	**4**	**0**	**0**	**0**
Parliament, composition, qualifications and disqualifications, powers and functions, executive, president, governor, council of ministers, judiciary, appointment and transfer of judges, qualifications, powers and functions					
Unit V	**LOCAL ADMINISTRATION**	**4**	**0**	**0**	**0**
Districts administration head: role and importance, municipalities: introduction, mayor and role of elected representative, CEO of municipal corporation. Panchayati raj: introduction, PRI: zilapanchayat. Elected officials and their roles, CEO zilapanchayat: position and role. Block level: organizational hierarchy(different departments), village level: role of elected and appointed officials, importance of grass root democracy					
Unit VI	**ELECTION COMMISSION**	**4**	**0**	**0**	**0**
Election Commission: role and functioning. Chief election commissioner and election commissioners. State election commission: role and functioning. Institute and bodies for the welfare of SC/ST/OBC and women					
	Total (24L+0T)= 24 Periods				

Suggested Reading:

1.	The Constitution of India, 1950 (Bare Act), Government Publication
2.	Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3.	M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4.	D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics
CO2	:	Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India
CO3	:	Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution
CO4	:	Discuss the passage of the Hindu Code Bill of 1956.

COURSE ARTICULATION MATRIX														
COs / POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1					1	1	1	1	1	1	1			
CO2					1	1	1	1	1	1	1			
CO3					1	1	1	1	1	1	1			
CO4					1	1	1	1	1	1	1			
Avg					1	1	1	1	1	1	1			
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)														

22AC06	PEDAGOGY STUDIES						SEMESTER I / II
PREREQUISTE		CATEGORY	AC	Credit			0
		Hours/Week	L	T		P	TH
			2	0		0	2

Course Objectives:

To Review existing evidence on the review topic to inform programme design and policy making undertaken by the DFID, other agencies and researchers. Identify critical evidence gaps to guide the development.

Unit I		4	0	0	0

Aims and rationale, Policy background, Conceptual framework and terminology, Theories of learning, Curriculum, Teacher education, Conceptual framework, Research questions, Overview of methodology and Searching

Unit II		2	0	0	0

Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries, Curriculum, Teacher education.

Unit III		4	0	0	0

Evidence on the effectiveness of pedagogical practices, Methodology for the in depth stage: quality assessment of included studies, How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? Theory of change. Strength and nature of the body of evidence for effective pedagogical practices, Pedagogic theory and pedagogical approaches, Teachers‟ attitudes and beliefs and Pedagogic strategies.

Unit IV		4	0	0	0

Professional development: alignment with classroom practices and follow-up support, Peer support, Support from the head teacher and the community, Curriculum and assessment, Barriers to learning: limited resources and large class sizes.

Unit V		2	0	0	0

Research gaps and future directions, Research design, Contexts, pedagogy, teacher education, curriculum and assessment, dissemination and research impact

Total (16L+0T)= 16 Periods

Suggested Reading:

1.	Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261
2.	Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379.
3.	Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID
4.	Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282.
5.	Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?
CO2	:	What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
CO3	:	How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

COURSE ARTICULATION MATRIX														
COs / POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1					1	1	1	1	1	1	1			
CO2					1	1	1	1	1	1	1			
CO3					1	1	1	1	1	1	1			
Avg					1	1	1	1	1	1	1			
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)														

22AC07	STRESS MANAGEMENT BY YOGA		SEMESTER I / II			
PREREQUISITE		**CATEGORY**	**AC**	**Credit**		**0**
		Hours/Week	**L**	**T**	**P**	**TH**
			2	**0**	**0**	**2**

Course Objectives:

To achieve overall health of body and mind, To overcome stress

Unit I	**8**	**0**	**0**	**0**

Definitions of Eight parts of yoga

Unit II	**8**	**0**	**0**	**0**

Yam and Niyam. Do`s and Don"t"s in life. 1.Ahinsa, satya, astheya, bramhacharya and aparigraha 2.Shaucha, santosh, tapa, swadhyay, ishwarpranidhan

Unit III	**8**	**0**	**0**	**0**

Asan and Pranayam 1. Various yog poses and their benefits for mind & body 2. Regularization of breathing techniques and its effects-Types of pranayama

Total (24L+0T)= 24 Periods

Suggested Reading:

1.	Yogic Asanas for Group Tarining-Part-I" :Janardan Swami Yogabhyasi Mandal, Nagpur "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Develop healthy mind in a healthy body thus improving social health .
CO2	:	Improve efficiency

COURSE ARTICULATION MATRIX

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1					1	1	1	1	1	1	1			
CO2					1	1	1	1	1	1	1			
Avg					1	1	1	1	1	1	1			

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

22AC08	PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS			SEMESTER I/ II			
PREREQUISTE			**CATEGORY**	**AC**	**Credit**		**0**
			Hours/Week	**L**	**T**	**P**	**TH**
				2	**0**	**0**	**2**

Course Objectives:

To learn to achieve the highest goal happily, To become a person with stable mind, pleasing personality and determination, To awaken wisdom in students.

		L	T	P	TH
Unit I	**NEETISATAKAM-HOLISTIC DEVELOPMENT OF PERSONALITY**	**8**	**0**	**0**	**0**

Verses- 19, 20, 21, 22 (wisdom)
Verses- 29, 31, 32 (pride & heroism)
Verses- 26, 28, 63, 65 (virtue)
Verses- 52, 53, 59 (dont‟s)
Verses- 71, 73, 75, 78 (do‟s)

Unit II	**APPROACH TO DAY TO DAY WORK AND DUTIES**	**8**	**0**	**0**	**0**

ShrimadBhagwadGeeta:
Chapter 2-Verses 41, 47,48,
Chapter 3-Verses 13, 21, 27, 35,
Chapter 6-Verses 5,13,17,23, 35,
Chapter 18-Verses 45, 46, 48.

Unit III	**STATEMENTS OF BASIC KNOWLEDGE**	**8**	**0**	**0**	**0**

Shrimad Bhagwad Geeta:
Chapter2-Verses 56, 62, 68
Chapter 12 -Verses 13, 14, 15, 16,17, 18
Personality of Role model.
Shrimad Bhagwad Geeta:
Chapter2-Verses 17,
Chapter 3-Verses 36,37,42
Chapter 4-Verses 18, 38,39
Chapter18 – Verses 37,38,63

Total (24L+0T)= 24 Periods

Suggested Reading:

1. “Srimad Bhagavad Gita” by Swami SwarupanandaAdvaita Ashram (Publication Department), Kolkata.
2. Bhartrihari‟s Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi.

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
CO2	:	The person who has studied Geeta will lead the nation and mankind to peace and prosperity
CO3	:	Study of Neetishatakam will help in developing versatile personality of students.

COURSE ARTICULATION MATRIX

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1					1	1	1	1	1	1	1			
CO2					1	1	1	1	1	1	1			
CO3					1	1	1	1	1	1	1			
Avg					1	1	1	1	1	1	1			

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)