DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

GOVERNMENT COLLEGE OF ENGINEERING, SALEM – 636 011.

(An Autonomous Instituion Affiliated to Anna University)

Curriculum 2018 - Autonomous Courses

(For Students Admitted from 2018 – 2019)

M.E. Power Electronics and Drives – Full Time

Course code	Name of the Course	Hours/Week						Maximum Marks		
		Category	Contact periods	Lecture	Tutorial/ Demo*	Practical	Credit	CA	FE	Total
SEMESTER I										
18PE**C**11	Power Semiconductor Devices and Components	Core	3	3	0	0	3	40	60	100
18PE**C**12	Analysis of Power Converters	Core	3	3	0	0	3	40	60	100
18PE**E**1X	Elective-I	Elect 1	3	3	0	0	3	40	60	100
18PE**E**2X	Elective-II	Elect 2	3	3	0	0	3	40	60	100
18PE**C**13	Advanced Power Electronics Laboratory-I	Core	4	0	0	4	2	40	60	100
18PE**C**14	Advanced Digital Control Laboratory	Core	4	0	0	4	2	40	60	100
18**MLC01**	Research Methodology and IPR	MLC	3	3	0	0	3	40	60	100
18ACXX	Audit Course	Audit	2	0	0	0	0	100	0	100
TOTAL							19			**800**
SEMESTER II										
18PE**C**21	Modelling and Analysis of Electrical Machines	Core	3	3	0	0	3	40	60	100
18PE**C**22	Modern Electrical Drives	Core	3	3	0	0	3	40	60	100
18PE**E**3X	Elective-III	Elect 3	3	3	0	0	3	40	60	100
18PE**E**4X	Elective-IV	Elect 4	3	3	0	0	3	40	60	100
18PE**C**23	Advanced Power Electronics Laboratory-II	Core	4	0	0	4	2	40	60	100
18PE**C**24	Advanced Electrical Drives Laboratory	Core	4	0	0	4	2	40	60	100
18PE**C**25	Mini Project With Seminar		4	0	0	4	2	40	60	100
18ACXX	Audit Course	Audit	2	0	0	0	0	100	0	100
TOTAL							18			**800**
SEMESTER III										
18PE**E**5X	Elective – V	Elect 5	3	3	0	0	3	40	60	100
18PE**E6**X	Elective - VI	Elect 6	3	3	0	0	3	40	60	100
18PE**C**31	Dissertation Phase – I		20	0	0	20	10	80	120	200
TOTAL							16			**400**
SEMESTER IV										
18PE**C**41	Dissertation Phase – II		32	0	0	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 1	
18PE**E**11	Advanced Microcontroller Based System Design
18PE**E**12	Applied Mathematics for Electrical Engineering
18PE**E**13	System Theory
18PE**E**14	Artificial Intelligence and Machine Learning
18PE**E**15	Discrete Control System
Elective II	
18PE**E**21	Advanced Power Electronic Circuits
18PE**E**22	Digital Signal Processing for Power Electronics
18PE**E**23	Dynamics of power Converters
18PE**E**24	Modulation Control for Power Converters
18PE**E**25	Design of Power Converters
Elective III	
18PE**E**31	Advanced Power Quality
18PE**E**32	Harmonics and Filters for Power Electronic Circuits
18PE**E**33	Energy Conservation, Auditing and Management
18PE**E**34	Special Electrical Machines and Drives
18PE**E**35	Digital Simulation of Power Electronics System
Elective – IV	
18PE**E**41	Photo Voltaic System
18PE**E**42	Optimization Techniques
18PE**E**43	Power System Optimization Techniques
18PE**E**44	Wind Energy System
18PE**E**45	Power Electronics for Renewable Energy System
Elective –V	
18PE**E**51	Smart Grid Technology
18PE**E**52	Distributed Generation

18PEE53	FACTS Controllers
18PEE54	HVDC Transmission Systems
18PEE55	SCADA Systems and Applications
Elective –VI	
18PEE61	Electric Vehicles
18PEE62	Theory and Design of SMPS
18PEE63	Energy Storage Technology
18PEE64	Internet of Things for Electrical Engineers
18PEE65	Digital Signal Processors for Power Converters

List of Audit Courses:

Course Code	**Name of Course**
18AC01	English for Research paper writing
18AC02	Disaster Management
18AC03	Sanskrit for Technical Knowledge
18AC04	Value Education
18AC05	Constitution of India
18AC06	Pedagogy Studies
18AC07	Stress Management by Yoga
18AC08	Personality Development through Life Enlightenment Skills

List of Special Electives:

Course Code	**Name of Course**
18PESE1	Pattern Recognition

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M.E. Power Electronics and Drives – Part Time

Course code	Name of the Course	Hours/Week						Maximum Marks		
		Category	Contact periods	Lecture	Tutorial/ Demo*	Practical	Credit	CA	FE	Total
SEMESTER I										
18PE**C**11	Power Semiconductor Devices and Components	Core	3	3	0	0	3	40	60	100
18PE**C**12	Analysis of Power Converters	Core	3	3	0	0	3	40	60	100
18PE**C**13	Advanced Power Electronics Laboratory-I	Core	4	0	0	4	2	40	60	100
18**MLC01**	Research Methodology and IPR	MLC	3	3	0	0	3	40	60	100
TOTAL							11			400
SEMESTER II										
18PE**C**21	Modelling and Analysis of Electrical Machines	Core	3	3	0	0	3	40	60	100
18PE**C**22	Modern Electrical Drives	Core	3	3	0	0	3	40	60	100
18PE**C**23	Advanced Power Electronics Laboratory-II	Core	4	0	0	4	2	40	60	100
18ACX	Audit Course	Audit	2	0	0	0	0	100	0	100
TOTAL							8			**400**
SEMESTER III										
18PE**E**1X	Elective-I	Elect 1	3	3	0	0	3	40	60	100
18PE**E**2X	Elective-II	Elect 2	3	3	0	0	3	40	60	100
18PE**C**14	Advanced Digital Control Laboratory	Core	4	0	0	4	2	40	60	100
18ACX	Audit Course	Audit	2	0	0	0	0	100	0	100
TOTAL							8			400
SEMESTER IV										
18PE**E**3X	Elective-III	Elect 3	3	3	0	0	3	40	60	100
18PE**E**4X	Elective-IV	Elect 4	3	3	0	0	3	40	60	100
18PE**C**24	Advanced Electrical Drives Laboratory	Core	4	0	0	4	2	40	60	100
18PE**C**25	Mini Project With Seminar	Core	4	0	0	4	2	40	60	100
TOTAL							10			**400**
SEMESTER V										
18PE**E**5X	Elective – V	Elect 5	3	3	0	0	3	40	60	100
18PE**E6**X	Elective - VI	Elect 6	3	3	0	0	3	40	60	100

18PE**C**31	Dissertation Phase – I	Core	20	0	0	20	10	80	120	200
TOTAL							16			**400**
SEMESTER VI										
18PE**C**41	Dissertation Phase – II		32	0	0	32	16	160	240	400
TOTAL							16			**400**

Total Credits for the programme = 11 + 8 + 8 + 10+16+16 = 69

List of Programme Electives:

Course Code	Name of Course
Elective 1	
18PE**E**11	Advanced Microcontroller Based System Design
18PE**E**12	Applied Mathematics for Electrical Engineering
18PE**E**13	System Theory
18PE**E**14	Artificial Intelligence and Machine Learning
18PE**E**15	Discrete Control System
Elective II	
18PE**E**21	Advanced Power Electronic Circuits
18PE**E**22	Digital Signal Processing for Power Electronics
18PE**E**23	Dynamics of power Converters
18PE**E**24	Modulation Control for Power Converters
18PE**E**25	Design of Power Converters
Elective III	
18PE**E**31	Advanced Power Quality
18PE**E**32	Harmonics and Filters for Power Electronic Circuits
18PE**E**33	Energy Conservation, Auditing and Management
18PE**E**34	Special Electrical Machines and Drives
18PE**E**35	Digital Simulation of Power Electronics System
Elective – IV	
18PE**E**41	Photo Voltaic System
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18PE**E**44	Wind Energy System

18PE**E**45	Power Electronics for Renewable Energy System
Elective –V	
18PE**E**51	Smart Grid Technology
18PE**E**52	Distributed Generation
18PE**E**53	FACTS Controllers
18PE**E**54	HVDC Transmission Systems
18PE**E**55	SCADA Systems and Applications
Elective –VI	
18PE**E**61	Electrical Vehicles
18PE**E**62	Theory and Design of SMPS
18PE**E**63	Energy Storage Technology
18PE**E**64	Internet of Things for Electrical Engineers
18PE**E**65	Digital Signal Processors for Power Converters

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18AC08	Personality Development through Life Enlightenment Skills

List of Special Electives:

Course Code	**Name of Course**
18PE**SE**1	Pattern Recognition

18PEC11	POWER SEMICONDUCTOR DEVICES AND COMPONENTS	L	T	P	C
		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**

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**

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**

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**

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**

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

Total (L+T)= 45 Periods

Course Outcomes:

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

CO1	*:*	*Remember the overview of power semiconductor switches*
CO2	*:*	*Analyze the thermal requirements of power semiconductor devices*
CO3	*:*	*Understand the basic concepts of ZVS and ZCS*
CO4	*:*	*Evaluate the design aspects of various magnetic components according to specific requirements.*
CO5	*:*	*Understand the design concepts of circuit elements*

Text Books:

1.	Rashid M.H., “Power Electronics: Circuits, Devices and Applications ", Pearson, 3rd Edition, 2013.
2.	Barry W Williams., “Power Electronics: Devices, Drivers, Applications, and Passive components”.

Reference Books:

1.	Mohan, Net al. “Power Electronics: Converters, Application and Design", Wiley India (P) Ltd, New Delhi, 2007.

PO / CO	CO Statement	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11
CO1	*Remember the overview of power semiconductor switches*	1	3	1	1	1	1	3	1	1	1	1
CO2	*Analyze the thermal requirements of power semiconductor devices*	1	1	3	3	1	1	3	1	1	2	1
CO3	*Understand the basic concepts of ZVS and ZCS*	1	1	2	2	2	1	1	1	1	3	1
CO4	*Evaluate the design aspects of various magnetic components according to specific requirements.*	2	3	2	3	3	1	2	2	1	2	2
CO5	*Understand the design concepts of circuit elements*	2	2	3	2	3	1	2	3	1	2	2

18PEC12	ANALYSIS OF POWER CONVERTERS	L	T	P	C
		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

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

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

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- power conditioners-UPS: offline UPS, online UPS.

Unit IV	THREE PHASE VOLTAGE SOURCE INVERTERS AND MULTI LEVEL CONVERTERS	9	+	0

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- 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

Operation of six-step thyristor inverter – inverter operation modes – load – commutated inverters – Auto sequential current source inverter (ASCI)– current pulsations –comparison of current source inverter and voltage source inverters – PWM techniques for current source inverters.

Total (L+T)= 45 Periods

Course Outcomes:

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

CO1	:	*Get expertise in the working modes and operation of Power converters.*
CO2	:	*Select and design dc-dc converter topologies for a broad range of power conversion applications.*
CO3	:	*Design single phase and three phase inverters*
CO4	:	*Formulate and design the inverters for generic loads and machine loads.*
CO5	:	*Acquire knowledge on multilevel inverters and modulation techniques*

Text Books:

1.	Mohan, Net al. "Power Electronics: Converters, Application and Design", Wiley India (P) Ltd, New Delhi, 3rd Edition 2010.
2.	Bimbhra, P.S, "Power Electronics ", Khanna Publishers, New Delhi, 4thEdition, 2012.
3.	Bimal K. Bose "Modern Power Electronics and AC Drives", Pearson Education, Second Edition, 2003.

Reference Books:	
1.	Murphy, J.M.D and Turnbull, F.G " Power Electronics Control of AC Motors ", Pergamon Press, Oxford, 1988.
2.	Rashid M.H., “Power Electronics: Circuits, Devices and Applications ", Pearson, 3rd Edition, 2014.
3.	P.C. Sen, “Modern Power Electronics”, Wheeler Publishing Co, First Edition, New Delhi, 1998.
4.	Jai P.Agrawal, “Power Electronics Systems”, Pearson Education, Second Edition, 2002

PO / CO	CO Statement	PO1	PO 2	PO 3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO1 1
CO1	*Get expertise in the working modes and operation of Power converters.*	3	3	1	1	1	1	2	3	1	1	1
CO2	*Select and design dc-dc converter topologies for a broad range of power conversion applications.*	2	2	2	1	2	1	2	3	1	1	2
CO3	*Design single phase and three phase inverters*	1	2	1	3	2	1	1	1	1	2	1
CO4	*Formulate and design the inverters for generic loads and machineloads.*	1	1	1	2	1	1	1	1	2	1	1
CO5	*Acquire knowledge on multilevel inverters and modulation techniques*	1	1	1	1	1	1	1	2	1	1	1

18PEC13	ADVANCED POWER ELECTRONICS LABORATORY-I	L	T	P	C
		0	0	4	2

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. Modelling of simple PN junction diodes
3. Modelling of SCR
4. Modelling of MOSFET / IGBT / BJT
5. Simulation of 1-phase semi-converter with R-load, RL load, and RLE (Motor) load
6. Simulation of 1-phase fully controlled converter with R-load, RL load, and RLE (motor) load at different firing angles.
7. Simulation of 1-phase dual converter.
8. Simulation of 3-phase semi-converter.
9. Simulation of 3-phase fully controlled converter at different firing angles.
10. Simulation of 1-phase full bridge inverter.
11. Simulation of 3-phase full bridge inverter.
12. Simulation of PWM inverter.
13. Simulation of 3-phase AC voltage controller.
14. Simulation of MOSFET / IGBT based choppers.
15. Simulation of DC-DC Buck-Boost converter with RL load.
16. Simulation of Series Resonant converter with RL load.
17. Numerical solution of ordinary differential, partial and integral equations using MATLAB.
18. Full converter fed resistive load
19. Full converter fed Resistive-Back Emf (RE) load at different firing angles
20. Full Converter fed Resistive-Inductive Load at different firing angles
21. Full converter fed DC motor load at different firing angles

Total (60+0)= 60 Periods

Course Outcomes:

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

CO1	:	*Model power electronics converter/Inverter in software*
CO2	:	*Simulate any power electronic converter/Inverter*
CO3	:	*Obtain numerical solutions of partial, differential and integral equations*
CO4	:	*Implement single phase full converter for any type of R and RL load*
CO5	:	*Implement single phase full converter for dc motors*

PO / CO	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	*Model power electronics converter/Inverter in software*	1	3	1	3	3	1	2	3	1	1	1
CO2	*Simulate any power electronic converter/Inverter*	1	1	2	1	3	1	2	3	1	1	1
CO3	*Obtain numerical solutions of partial, differential and integral equations*	1	2	1	3	2	1	1	1	1	1	2
CO4	*Implement single phase full converter for any type of R and RL load*	1	1	1	3	3	1	2	2	1	2	1
CO5	*Implement single phase full converter for dc motors*	1	1	1	1	3	1	1	2	2	1	1

18PEC14	ADVANCED DIGITAL CONTROL LABORATORY	L	T	P	C
		0	0	4	2

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

Course Outcomes:

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

CO1	:	*Understand the peripheral requirements for controlling the circuit*
CO2	:	*Understand and implement the configurations of various required peripherals*
CO3	:	*Write coding to implement the devised control technique*
CO4	:	*Understand and implement the measurement principles through digital techniques*
CO5	:	*Develop algorithms for implementation of controls and implement isolation techniques for power control*

PO / CO	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	*Understand the peripheral requirements for controlling the circuit*	1	1	1	1	1	1	1	1	1	1	1
CO2	*Understand and implement the configurations of various required peripherals*	1	1	1	1	1	1	1	1	1	1	1
CO3	*Write coding to implement the devised control technique*	1	1	1	1	1	1	1	1	1	1	1
CO4	*Understand and implement the measurement principles through digital techniques*	1	1	1	1	1	1	1	1	1	1	1
CO5	*Develop algorithms for implementation of controls and implement isolation techniques for power control*	1	1	1	1	1	1	1	1	1	1	1

18MLC01	RESEARCH METHODOLOGY AND IPR	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

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

UNIT I	INTRODUCTION TO RESEARCH	9	+	0

Meaning of research problem, Sources of the 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

Developing the theoretical framework of the 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

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

UNIT IV	NATURE OF INTELLECTUAL PROPERTY	9	+	0

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

UNIT V	PATENT RIGHTS AND IPR	9	+	0

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

Total = 45 Periods

COURSE OUTCOMES:

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

CO1	*:*	*Understand research problem formulation.*
CO2	*:*	*Analyze research-related information*
CO3	*:*	*Follow research ethics*
CO4	*:*	*Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.*
CO5	*:*	*Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to the creation of new and better products, and in turnbrings about, economic growth and social benefits.*

TEXT 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.

REFERENCE BOOKS:

1.	Mayall, “Industrial Design”, McGraw Hill, 1992.
2.	Niebel, “Product Design”, McGraw Hill, 1974.
3.	Asimov, “Introduction to Design”, Prentice Hall, 1962.
4.	Robert P. Merges, Peter S. Menell, Mark A. Lemley, “Intellectual Property in New Technological Age”, 2016.
5.	T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008

PO / CO	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	*Understand research problem formulation.*					1	1	1	1	1	2	1
CO2	*Analyze research-related information*					3	1	1	1	1	1	1
CO3	*Follow research ethics*					1	1	1	1	3	1	1
CO4	*Understand that today’s world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.*					1	3	1	1	1	1	1
CO5	*Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to the creation of new and better products, and in turnbrings about, economic growth and social benefits.*					1	3	1	1	1	2	2

18PEC21	MODELLING AND ANALYSIS OF ELECTRICAL MACHINES	L	T	P	C
		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

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

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	9	+	0

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

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	SPECIAL MACHINES	9	+	0

Permanent magnet and characteristics - Synchronous machines with PMs: Machine configuration - flux density distribution - types of PMSM - Variable Reluctance Machines: principle of operation - torque production - Stepping motors: principle of operation- types: Variable reluctance – Hybrid motor – Torque equation - characteristics.

Total (L+T)= 45 Periods

Course Outcomes:

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

CO1	:	*Acquire knowledge about the DC machines and AC machines and their magnetic circuits.*
CO2	:	*develop mathematical model of AC & DC machines and perform transient analysis on them.*
CO3	:	*Understand the different types of reference frame theories and transformation relationships.*
CO4	:	*Analyze the steady state and dynamic operation of three phase induction motor using transformation theory based mathematical Modelling and Special machines.*
CO5	:	*Select strategies to control the torque for a given application.*

Text Books:

1. R.Krishnan,"Electric motor drives: modelling, analysis, and control", prentice hall of India, 2010

2.	P.S.Bimbra,"generalized theory of Electric machines", khanna publishers, 5th Edition, 2007.
Reference Books:	
1.	Charles Kingley, Jr., A.E.Fitzgerald, Stephen D.Umans, "Electric Machinery",Tata McGraw Hill, 6th Edition, 2002.
2	Miller, T.J.E., "Brushless Permanent Magnet and Reluctance Motor Drives", Clarendon Press

PO / CO	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	*Acquire knowledge about the DC machines and AC machines and their magnetic circuits.*	2	1	1	1	3	1	3	1	1	1	1
CO2	*develop mathematical model of AC & DC machines and perform transient analysis on them.*	2	1	3	3	1	1	3	1	1	1	1
CO3	*Understand the different types of reference frame theories and transformation relationships.*	2	2	2	2	3	1	3	1	1	3	1
CO4	*Analyze the steady state and dynamic operation of three phase induction motor using transformation theory based mathematical Modelling and Special machines.*	2	3	2	3	3	1	2	2	1	2	1
CO5	*Select strategies to control the torque for a given application.*	2	2	3	3	3	1	2	1	1	2	2

18PEC22	MODERN ELECTRICAL DRIVES	L	T	P	C
		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**

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**

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**

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**

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**

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

Total (L+T)= 45 Periods

Course Outcomes:

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

CO1	:	*Understand selection of drives for industries.*
CO2	:	*Analyse various characteristics of series and separately excited DC motor with single and three phase converters.*
CO3	:	*Explain about different conventional speed control methods for induction motors.*
CO4	:	*Explain about direct and indirect methods of field oriented control and direct Torque Control scheme for Induction motor.*
CO5	:	*Formulate the control schemes for synchronous motor drives.*

Text Books:

1.	Dubey,G.K. "Power Semiconductor Controlled Drives ", PH International, New Jersey, 1989.
2.	Sen, P.C. "Thyristor D.C Drives ", John Wiley & Sons, New York, 1981.
3.	Bimal K Bose, “Modern Power Electronics and AC Drives”, Pearson Education Asia 2004.

4.	R.Krishnan, “Electric Motor Drives – Modeling, Analysis and Control”, Prentice-Hall of India Pvt. Ltd., New Delhi, 2003.
Reference Books:	
1.	Subharamanyam V. "Electric Drives-Concepts and Applications ", TMH Publi., 1994
2.	GobalK.Dubey, “Fundamentals of Electrical Drives”, Narosal Publishing House, New Delhi,Second Edition ,2009.
3.	W.Leonhard, “Control of Electrical Drives”, Narosa Publishing House, 1992.
4.	Murphy J.M.D and Turnbull, “Thyristor Control of AC Motors”, Pergamon Press, Oxford, 1988

PO / CO	CO Statement	PO1	PO 2	PO 3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO1 1
CO1	*Understand selection of drives for industries.*	1	1	1	1	2	1	2	1	2	1	2
CO2	*Analyse various characteristics of series and separately excited DC motor with single and three phase converters.*	1	3	3	2	2	1	2	2	1	1	1
CO3	*Explain about different conventional speed control methods for induction motors.*	1	1	1	2	2	1	1	2	1	1	1
CO4	*Explain about direct and indirect methods of field oriented control and direct Torque Control scheme for Induction motor.*	1	1	2	2	2	1	2	2	1	1	1
CO5	*Formulate the control schemes for synchronous motor drives.*	1	2	3	2	3	1	2	2	1	1	1

18PEC23	ADVANCED POWER ELECTRONICS LABORATORY II	L	T	P	C
		0	0	4	2

Course Objectives:

1. To provide an insight on the switching behaviours 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 modelling of power electronic circuits and implementing the same using simulation tools

LIST OF EXPERIMENTS:

1. Dynamic characteristics of SCR and TRIAC
2. Dynamic characteristics of MOSFET, BJT and IGBT
3. Single phase ac voltage controller using SCR and TRIAC
4. Three phase half and fully controlled bridge converter
5. Single phase series inverter
6. IGBT based three phase PWM Inverter
7. MOSFET based buck boost converter
8. DC-DC forward converter
9. DC-DC flyback converter
10. Single phase dual converter
11. DC series resonant converter

Total (60+0)= 60 Periods

Course Outcomes:

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

CO1	*:*	*Implement ac voltage controller*
CO2	*:*	*Obtain the performance of any type of converter*
CO3	*:*	*Analyse the performance of single phase and three phase inverter*
CO4	*:*	*Implement DC-DC converter*
CO5	*:*	*Analyse the performance of resonant converter*

PO / CO	CO Statement	PO1	PO 2	PO 3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO1 1
CO1	*Implement ac voltage controller*	2	1	3	3	3	1	2	3	2	1	2
CO2	*Obtain the performance of any type of converter*	2	3	3	1	3	1	2	3	1	1	1
CO3	*Analyse the performance of single phase and three phase inverter*	2	3	1	1	2	1	1	1	1	1	1
CO4	*Implement DC-DC converter*	1	1	3	3	3	1	2	3	1	1	1
CO5	*Analyse the performance of resonant converter*	2	3	3	1	3	1	2	3	1	1	1

18PEC24	ADVANCED ELECTRICAL DRIVES LABORATORY	L	T	P	C
		0	0	4	2

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

Course Outcomes:

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

CO1	:	*Design closed loop control for PMSM and SRM drives.*
CO2	:	*Analyze the operation of VSI and CSI fed induction motor drives*
CO3	:	*Select suitable inverter configuration and control for three phase induction motor drives.*
CO4	:	*Analyze the operation of synchronous motor drives.*
CO5	:	*Use digital control for special motor drives.*

PO / CO	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	*Design closed loop control for PMSM and SRM drives.*	2		3	2		1		2		1	
CO2	*Analyze the operation of VSI and CSI fed induction motor drives*	1	3						1			
CO3	*Select suitable inverter configuration and control for three phase induction motor drives.*	3		1					1			2
CO4	*Analyze the operation of synchronous motor drives.*	1	3						2			
CO5	*Use digital control for special motor drives.*	2			3	1			1			

18PEE11	ADVANCED MICROCONTROLLER BASED SYSTEM DESIGN	L	T	P	C
		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

dsPIC 30F CPU Core – Programmers Model – CPU Registers – DSP Engine – Memory Organization – Data – Program – Flash and EEPROM Programming.

Unit II	SYSTEM CONFIGURATION	9	+	0

Oscillator Configuration – Power saving Modes - Various Resets – Device Configuration – Low Voltage Detect - I/O Ports

Unit III	CONTROL PERIPHERALS	9	+	0

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

Motor Control PWM – Different PWM modes – Dead Time – Output and Polarity Control – PWM Fault Pins – Quadrature Encoder Interface

Unit V	APPLICATIONS	9	+	0

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 (L+T)= 45 Periods

Course Outcomes:

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

CO1	:	*Understand various DSP peripherals*
CO2	:	*Understand the configurations of peripherals for appropriate power applications*
CO3	:	*Write C coding for implementing controls using peripherals*
CO4	:	*Implement interfacing techniques with DSC for control applications*
CO5	:	*Understand and implement data acquisition and processing for control application and implement control techniques for power electronic applications*

Reference Books:

1.	dsPIC30FFamily 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

PO / CO	CO Statement	PO1	PO 2	PO 3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO1 1
CO1	*Understand various DSP peripherals*	1	1	1	1	1		1	1	1	1	1
CO2	*Understand the configurations of peripherals for appropriate power applications*	1	1	1	1	1		1	1	1	1	1
CO3	*Write C coding for implementing controls using peripherals*	1	1	1	1	1		1	1	1	1	1
CO4	*Implement interfacing techniques with DSC for control applications*	1	1	1	1	1		1	1	1	1	1

CO5	*Understand and implement data acquisition and processing for control application and implement control techniques for power electronic applications*	1	1	1	1	1		1	1	1	1	1

18PEE12	APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERING	L	T	P	C
		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

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

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

Numerical solution of ordinary Differential Equations-Euler' method-Euler's modified method – Taylor's method and Runge – Kutta method for simultaneous equations and 2^{nd} order equations – Multistep methods – Milne's and Adam's methods.

Unit IV	LINEAR PROGRAMMING	9	+	0

Basic concepts – Graphical and Simplex methods – Transportation problem – Assignment problem

Unit V	DYNAMIC PROGRAMMING	9	+	0

Elements of the dynamic programming model – optimality principle –Examples of dynamic programming models and their solutions.

Total (L+T)= 45 Periods

Course Outcomes:

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

CO1	:	*Understand the concept of variational problems and its techniques.*
CO2	:	*Solve the linear equations*
CO3	:	*Obtain the numerical solutions of differential equations*
CO4	:	*Solve the Transportation and Routing problems using Optimization Techniques*
CO5	:	*Gain the knowledge and concept of Dynamic Problems and techniques to solve*

Text Books:

1.	Grewal, B.S., Higher Engineering Mathematics, 43^{rd} 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, 7^{th} edition, New Delhi, 2006
4.	Taha, H.A., "Operations research – An Introduction", 9^{th} Edition, Pearson Education Edition, Asia, New Delhi (2014).
5.	Kanti Swarup, P.K.Gupta & Man Mohan" Operation Research", 17^{th} Edition, Reprint 2014. JBA Publishers. New Delhi.

PO / CO	CO Statement	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11
CO1	*Understand the concept of variational problems and its techniques.*			3	1	1	1	1	1	1	1	1
CO2	*Solve the linear equations*			3	1	1	2	2	1	1	1	1
CO3	*Obtain the numerical solutions of differential equations*			3	1	1	2	1	1	2	1	3
CO4	*Solve the Transportation and Routing problems using Optimization Techniques*			1	1	1	1	2	1	1	1	1
CO5	*Gain the knowledge and concept of Dynamic Problems and techniques to solve*			1	1	1	2	1	1	1	1	3

18PEE13	SYSTEM THEORY	L	T	P	C
		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

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

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

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

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

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 (L+T)= 45 Periods

Course Outcomes:

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

CO1	*:*	*Understand the concept of state variable representation of systems.*
CO2	*:*	*Solve linear and non-linear state equations.*
CO3	*:*	*Explain the concepts of controllability and observability.*
CO4	*:*	*Have the better understanding of Stability analysis of nonlinear systems.*
CO5	*:*	*Understand the concepts of Pole placement and State feedback.*

Text Books:

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.

Reference Books:

1.	Bubnicki, Z., "Modern Control Theory", Springer Publishers, 2005.
2.	Ogatta, K., "Modern Control Engineering", Prentice Hall of India, 2002.

PO / CO	CO Statement	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11
CO1	*Understand the concept of state variable representation of systems.*	1	3	1	1	2	1	3	1	1	1	1
CO2	*Evaluate linear and non-linear state equations.*	1	1	3	3	1	2	3	1	1	2	1
CO3	*Analyze the concepts of controllability and observability.*	1	1	2	2	2	2	1	1	2	3	1
CO4	*Apply Stability concept to nonlinear systems.*	2	3	2	3	3	1	2	2	1	2	2
CO5	*Understand the concepts of Pole placement and State feedback.*	2	2	3	2	3	1	2	3	1	2	2

18PEE14	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING	L	T	P	C
		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, natural languahe processing, pattern recognition and speech recognition, etc.
5.	To apply AI techniques primarily for machine learning, vision, and robotics.

Unit I	INTRODUCTION TO AI AND PRODUCTION SYSTEMS	9	+	0

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

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

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

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

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 (L+T)= 45 Periods

Course Outcomes:

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

CO1	*:*	*Provide a basic exposition to the goals and methods of Artificial Intelligence.*
CO2	*:*	*Study the design of intelligent computational agents.*
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.*
CO4	*:*	*Apply innate human skills such as automatic programming, case – based reasoning, neural networks, Fuzzy Logic, decision-making, expert systems, natural languahe processing, pattern recognition and speech recognition, etc.*
CO5	*:*	*Enhance their knowledge in their Research works in future.*
CO6	*:*	*Build new solutions in business in future.*

Text Books:

1.	Stuart Russell, Peter Norvig, “Artificial Intelligence: A Modern Approach”, Third Edition, Pearson Education / Prentice Hall of India, 2010.
2.	Elaine Rich and Kevin Knight, “Artificial Intelligence”, Third Edition, Tata McGraw-Hill, 2010.
3.	Ethem Alpaydin, “Introduction to Machine Learning (Adaptive Computation and Machine Learning series)”, The MIT Press; Second edition, 2009.
4.	Patrick H. Winston. "Artificial Intelligence", Third edition, Pearson Edition, 2006.

Reference Books:

1.	Bratko I, “Prolog Programming for Artificial Intelligence”, Addison-Wesley Educational Publishers Inc;

	Fourth Edition, 2011.
2.	David L. Poole, Alan K. Mackworth, “Artificial Intelligence: Foundations of Computational Agents”, Cambridge University Press, 2010.
3.	Dan W.Patterson, “Introduction to Artificial Intelligence and Expert Systems”, PHI, 2006.
4.	Nils J. Nilsson, “Artificial Intelligence: A new Synthesis”, Harcourt Asia Pvt. Ltd., 2000.

PO / CO	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	*Provide a basic exposition to the goals and methods of Artificial Intelligence.*	2	2	2	1	1	1	2	1	1	2	1
CO2	*Study the design of intelligent computational agents.*	3	1	1	2	2	1	1	1	2	2	1
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.*	1	1	1	2	1	1	2	2	2	2	2
CO4	*Apply innate human skills such as automatic programming, case – based reasoning, neural networks, Fuzzy Logic, decision-making, expert systems, natural languahe processing, pattern recognition and speech recognition, etc.*	1	2	2	3	3	1	1	2	1	1	1
CO5	*Enhance their knowledge in their Research works in future.*	1	1	1	1	1	2	2	1	2	1	1
CO6	*Build new solutions in business in future.*	1	1	1	2	1	1	1	2	3	3	3

18PEE15	DISCRETE CONTROL SYSTEM	L	T	P	C
		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

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

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

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

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

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 (L+T)= 45 Periods

Course Outcomes:

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

CO1	:	*Get knowledge about digital control scheme.*
CO2	:	*Get knowledge about sampling techniques.*
CO3	:	*Design the various digital control algorithms.*
CO4	:	*Design the various types of digital controllers and compensators.*
CO5	:	*Get knowledge about applications of digital control.*

Text Books:

1.	M.Gopal, "Digital Control and Static Variable Methods", Tata McGraw Hill, New Delhi, 2012, 4th Edition.
2.	I.J.Nagrath & M.Gopal, "Control Systems Engineering", New Age International Publishers, New Delhi, 2017,6th Edition.

Reference Books:

1.	B.C.Kuo, Digital Control Systems, Oxford University Press,2nd Edition,2007.
2.	K. Ogata, Modern Control Engineering, Pearson Education, 2002.
3.	Kenneth J. Ayala, "The 8051 Microcontroller- Architecture, Programming and Applications", Penram International, 2nd Edition, 1996.

PO / CO	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	*Get knowledge about digital control scheme.*	1	1	1	1	1	1	1	1	1	2	1
CO2	*Get knowledge about sampling techniques.*	1	1	1	1	1	1	1	1	1	2	1
CO3	*Design the various digital control algorithms.*	1	1	2	2	3	1	3	2	1	2	1
CO4	*Design the various types of digital controllers and compensators.*	1	3	3	3	3	1	3	3	1	2	1
CO5	*Get knowledge about applications of digital control.*	2	2	3	3	3	1	2	3	1	2	1

18PEE21	ADVANCED POWER ELECTRONIC CIRCUITS	L	T	P	C
		3	0	0	3

Course Objectives:

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

Unit I	MULTIPULSE CONVERTERS	9	+	0

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

Forward converter, Half bridge and full-bridge converters , SEPIC Converter; Interleaved boost converter, transformer-isolated topologies, continuous and discontinuous conduction modes of operation, ripple analysis

Unit III	HIGH POWER CONVERTERS	9	+	0

Multi-Level Inverters of Diode Clamped Type and Flying Capacitor Type 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

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	EMI AND FILTERING	9	+	0

EMI Generation and Filtering in power converters - Conducted and Radiated Emission Mechanisms. Techniques to reduce Emissions. Shielding and Grounding. Power Circuit Layout for minimum EMI. EMI Filtering at Input and Output. Effect of EMI Filter on converter Control Dynamics

Total (L+T)= 45 Periods

Course Outcomes:

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

CO1	:	*Know the operating modes of new DC-DC voltage regulators*
CO2	:	*Select appropriate phase shifting converter for a multi-pulse converter operation*
CO3	:	*Design an inverter configuration for high power AC applications*
CO4	:	*Use of bidirectional converters with optimal component selection*
CO5	:	*Analyze hard-switched converters with appropriate control methods*

Reference Books:

1. Bin Wu, “High Power Converters and AC Drives”, John Willey & sons, Inc., 2006.
2. N. Mohan, Power Electronics: A First Course, John Wiley & Sons, 2012.
3. B. K Bose “Modern Power Electronics and AC Drives” Pearson Education, 2007.

PO CO	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11
CO1	*Know the operating modes of new DC-DC voltage regulators*	2		1					2			1
CO2	*Select appropriate phase shifting converter for a multi-pulse converter operation*	1				2	1					
CO3	*Design an inverter configuration for high power AC applications*		1		2							2
CO4	*Use of bidirectional converters with optimal component selection*			3	1							2
CO5	*Analyze hard-switched converters with appropriate control methods*		3						1			

18PEE22	DIGITAL SIGNAL PROCESSING FOR POWER ELECTRONICS	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To understand the need for filter, its design
2.	To learn selection of sensor and transducers to power applications and choice of conditioning
3.	To know different sampling techniques in AD converters
4.	To learn Digital filters and its design
5.	To understand and learn different parameter measurements

Unit I	INTRODUCTION TO DIGITAL SIGNAL PROCESSING	9	+	0

A/D Converters – Quantization Errors – Sampling – Sample and Hold Circuit – Sampling Theorem – Aliasing – Anti-Aliasing Filter and its Design - Total Harmonic Distortion

Unit II	INSTRUMENTATION AND CONTROL INTERFACES	9	+	0

Data Acquisition – Sensors and Transducers – Electronic Interface – Signal Conditioning Circuits – Circuits based on Operational Amplifier – Galvanic isolation

Unit III	ANALOG SIGNAL DISCRETIZATION	9	+	0

Sampling –Sequential – Simultaneous – Errors in Sampling – A/D Converters suitable for Power Electronics

Unit IV	SIGNAL FILTRATION AND SEPARATION	9	+	0

Derivative and Integral Value calculation - Digital Filters – Moving Average Filter - FIR – IIR – Design of filters - Implementation

Unit V	PARAMETER MEASUREMENTS	9	+	0

Algorithms – Measurement of Voltage and Current – Average – True RMS – Power – Average – Apparent – Power Factor – Reverse Power Flow – Energy – Fundamental Component identification – THD evaluation – Sequence Component identification

Total (L+T)=45 Periods

Course Outcomes:

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

CO1	*:*	*Understand errors in quantization and select appropriate anti-aliasing filter*
CO2	*:*	*Select and Design the suitable circuit for data acquisition*
CO3	*:*	*Select the correct AD converter and sampling technique*
CO4	*:*	*Choose and design appropriate software filter*
CO5	*:*	*Understand and implement measurement and processing for control application and develop, implement algorithms for parameter measurement*

Reference Books:

1.	Krzysztof Sozański, “Digital Signal Processing in Power Electronics ControlCircuits”, 2nd Edition, Springer, 2017
2.	Oppenheim, A.V., Schafer, R.W. and Buck, J.R., Discrete-Time Signals Processing, 2nd Edition, Prentice Hall, Englewood Cliffs, 1999.
3.	Arrillage, J., Smith, B.C., Watson, N.R. and Wood, A.R., Power System Harmonic Analysis, John Wiley & Sons, Inc., Hoboken
4.	Bhide S.R., “Digital Power System Protection”, Prentice Hall India, 2014
5.	Destro, R., Matakas, L., Komatsu, W. and Ama, N.R.N., “Implementation aspects of adaptive window moving average filter applied to PLLs—comparative study”, in Brazilian Power Electronics Conference (COBEP), Gramado, IEEE, pp. 730–736, 2013.

PO / CO	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	*Understand errors in quantization and select appropriate anti-aliasing filter*	1	1	1	1	2						1
CO2	*Select and Design the suitable circuit for data acquisition*	1	1	1	1	1			1			1
CO3	*Select the correct AD converter and sampling technique*	1	1	2	2	1			1			1
CO4	*Choose and design appropriate software filter*	1	2	1	1	1			1			1
CO5	*Understand and implement measurement and processing for control application and develop, implement algorithms for parameter measurement*	1	1	1	1	1			1			1

18PEE23	DYNAMICS OF POWER CONVERTERS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To provide knowledge in dynamic behavior and analyses of the DC-DC converters and three phase grid connected converters with source and load interactions.

Unit I	INTRODUCTION TO DYNAMIC ANALYSIS	9	+	0

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

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

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

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

Three Phase active rectifier -Power stage and Equivalent switch matrix- Equivalent circuit model- State space model- Control of active rectifier using transfer matrices- Open-Loop and closed loop control scheme

Total (L+T)= 45 Periods

Course Outcomes:

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

CO1	*:*	*Know the dynamic representations of power converters*
CO2	*:*	*Make a dynamic model of DC-DC converter*
CO3	*:*	*Select appropriate control scheme for DC-DC converter with its dynamic model*
CO4	*:*	*Develop state space model for three phase converters*
CO5	*:*	*Design a suitable controller for for three phase converters*

Reference Books:

1. Teuvo Suntio, "Power Electronic Converters:Dynamics and Control in Conventional and Renewable Energy 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.

PO / CO	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11
CO1	*Know the dynamic representations of power converters*	2		3			1	1				
CO2	*Make a dynamic model of DC-DC converter*	1			2				2			2
CO3	*Select appropriate control scheme for DC-DC converter with its dynamic model*		2			3			1			2
CO4	*Develop state space model for three phase converters*			1		1						
CO5	*Design a suitable controller for three phase converters*	1			2						1	

18PEE24	MODULATION CONTROL FOR POWER CONVERTERS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To understand Necessity and Importance of PWM techniques
2. Implementation of PWM controllers

Unit I	**INTRODUCTION**	**9**	**+**	**0**

Introduction to PE converters, Modulation of one inverter phase leg, Modulation of single phase, VSI and 3 phase VSI.

Unit II	**MODULATION STRATEGIES**	**9**	**+**	**0**

Zero space vector placement modulation strategies, Losses-Discontinuous modulation, Modulation of CSI.

Unit III	**OVER MODULATION**	**9**	**+**	**0**

Over modulation of converters, programme modulation strategies.

Unit IV	**IMPLEMENTATION OF MODULATION CONTROLLER**	**9**	**+**	**0**

Pulse width modulation for multilevel inverters, Implementation of modulation controller

Unit V	**PWM**	**9**	**+**	**0**

Continuing developments in modulation as random PWM, PWM for voltage unbalance, Effect of minimum pulse width and dead time

Total (L+T)= 45 Periods

Course Outcomes:

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

CO1	:	*Remember the basic concepts of power electronic converters.*
CO2	:	*Understand and evaluate the modulation strategies.*
CO3	:	*Understand the concepts of over modulation of converters.*
CO4	:	*Apply the concept of pulse width modulation for inverters.*
CO5	:	*Evaluate the practices and suggest suitable measures for continuous developments in modulation.*

Reference Books:

1. D. Grahame Holmes, Thomas A. Lipo, “Pulse width modulation of Power Converter: Principles and Practice”, John Wiley & Sons, 03-Oct-2003
2. Bin Vew, “High Power Converter”, Wiley Publication
3. Marian K. Kazimicrczuk, “Pulse width modulated dc-dc power converter”, Wiley Publication

PO / CO	CO Statement	PO1	PO 2	PO 3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO1 1
CO1	*Remember the basic concepts of power electronic converters.*	3	1	1	1	1		1	1	1	1	1
CO2	*Understand and evaluate the modulation strategies.*	2	1	1	3	1		1	1	1	1	1
CO3	*Understand the concepts of over modulation of converters.*	2	1	1	3	1		1	1	1	1	1
CO4	*Apply the concept of pulse width modulation for inverters.*	3	1	1	1	1		1	1	1	1	1
CO5	*Evaluate the practices and suggest suitable measures for continuous developments in modulation.*	2	1	1	1	1	1	3	1	1	1	1

18PEE25	DESIGN OF POWER CONVERTERS	L	T	P	C
		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

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

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

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

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

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 (L+T)= 45 Periods

Course Outcomes:

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

CO1	*:*	*Understand design concepts and flow*
CO2	*:*	*Select the appropriate circuit topology for applications*
CO3	*:*	*Select the appropriate power devices*
CO4	*:*	*Select and design the appropriate circuit to meet the design metrics*
CO5	*:*	*Select the circuit configuration for electrical protection and scheme for thermal protection and derive methodology for selection of appropriate circuit for applications.*

Reference Books:

1.	Muhammad H. Rashid - Power Electronics Devices, Circuits, and Applications 4 Edition, Pearson 2014.
2.	Barry W. Williams - Principles and Elements of Power Electronics – Devices, Drivers, Applications and Passive Components, ISBN 978-0-9553384-0-3.

PO / CO	CO Statement	PO1	PO 2	PO 3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO1 1
CO1	*Understand design concepts and flow*	1	1	1	1	1		1	1	1	1	1
CO2	*Select the appropriate circuit topology for applications*	1	1	1	1	1		1	1	1	1	1
CO3	*Select the appropriate power devices*	1	1	1	1	1		1	1	1	1	1
CO4	*Select and design the appropriate circuit to meet the design metrics*	1	1	1	1	1		1	1	1	1	1
CO5	*Select the circuit configuration for electrical protection and scheme for thermal protection and derive methodology for selection of appropriate circuit for applications.*	1	1	1	1	1		1	1	1	1	1

18PEE31	ADVANCED POWER QUALITY	L	T	P	C
		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**

Introduction – Characterisation 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, Non linear 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**

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**

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**

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

Unit V	**SERIES COMPENSATION USING DVR**	**9**	**+**	**0**

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 voltage 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 (45+0)= 45 Periods

Course Outcomes:

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

CO1	:	*Understand the various power quality issues.*
CO2	:	*Analyse the single and three-phase circuits under non-sinusoial and unbalanced load conditions*
CO3	:	*Understand the conventional load compensation theories*
CO4	:	*Realize of DSTATCOM*
CO5	:	*Gain knowledge on series compensation using DVR*
CO6	:	*Understand the operation of UPQC*

Text Books:

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, 2002.
3.	NPTEL course module of power quality in power distribution systems.

Reference Books:	
1.	A. J. Arrillaga, “Power System Harmonics”, John Wiley & Sons, 2nd Edition, 2003.
2	G.T.Heydt, “Electric Power Quality”, McGraw-Hill Professional, 2007.
3	Math H. Bollen, “Understanding Power Quality Problems”, IEEE Press, 2000

PO / CO	CO Statement	PO1	PO 2	PO 3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11
CO1	*Understand the various power quality issues.*	2	1	3	3	1	1				1	1
CO2	*Analyze the single and three-phase circuits under non-sinusoidal and unbalanced load conditions*	2	3	2	1	1	1				1	1
CO3	*Understand the conventional load compensation theories*	2	3	2	3	2	1	1	1		1	1
CO4	*Realize of DSTATCOM*	2	3	2	2	2	2	1	1		2	1
CO5	*Gain knowledge on series compensation using DVR*	2	3	2	2	2	2	1	1		2	1
CO6	*Understand the operation of UPQC*	2	3	2	2	2	2	1	1		2	1

18PEE32	HARMONICS AND FILTERS FOR POWER ELECTRONIC CIRCUITS	L	T	P	C
		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**

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**

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**

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**

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**

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

Total (L+T)= 45 Periods

Course Outcomes:

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

CO1	*:*	Understand the fundamentals of harmonics
CO2	*:*	Analyze and design of passive power filter
CO3	*:*	Analyze and design of shunt active power filter
CO4	*:*	Analyze and design of series active power filter
CO5	*:*	Analyze and design of hybrid active power filter

Text Books:

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.

Reference Books:

1.	A.J.Arrillaga , "Power System Harmonics", John Wiley and Sons Limited, Second Edition, 2003
2.	G.T.Heydt, "Electric Power Quality", McGraw – Hill professional, 2007.

PO / CO	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	*Understand the fundamentals of harmonics*	1	1	3	2	3	1	1	1	1	1	1
CO2	*Analyze and design of passive power filter*	1	3	2	2	1	1	1		1	1	1
CO3	*Analyze and design of shunt active power filter*	1	3	2	2	1	1	1		1	1	1
CO4	*Analyze and design of series active power filter*	1	3	2	2	1	1	1		1	1	1
CO5	*Analyze and design of hybrid active power filter*	1	3	2	2	1	1	1		1	1	1

18PEE33	ENERGY CONSERVATION, AUDITING AND MANAGEMENT	L	T	P	C
		3	0	0	3

Course Objectives:

1.	*To understandthe energy conservation concepts.*
2.	*To know about electrical energy management.*

Unit I	ENERGY SCENARIO	9	+	0

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

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

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

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

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 (L+T)= 45 Periods

Course Outcomes:

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

CO1	*:*	*Understand the present energy scenario.*
CO2	*:*	*Get fundamental knowledge about energy and its various forms.*
CO3	*:*	*Understand the process of energy management and energy auditing.*
CO4	*:*	*Understand the methods improving energy efficiency.*
CO5	*:*	*Understand the concepts of energy efficient devices.*

Reference Books:

1.	*Handbook of Energy Audit, Sonal Desai, McGraw Hill, 2015.*
2.	*Utilization of Electrical Energy and Conservation, S.C. Tripathy,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.	*Energy Management, W.R. Murphy&G. McKay, Butterworths Publications, 1981.*
6.	*Energy Management Hand Book, Wayne C Tuner, John Wiley and Sons, 6th edition, 2006.*

PO / CO	CO Statement	PO1	PO 2	PO 3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO1 1
CO1	*Understand the present energy scenario.*	1	1	1	1	1	1	3	1	1	1	1
CO2	*Get fundamental knowledge about energy and its various forms.*	1	1	3	3	1	1	3	1	1	2	1
CO3	*Understand the process of energy management and energy auditing.*	1	1	2	2	2	1	1	1	1	3	1
CO4	*Understand the methods improving energy efficiency.*	2	3	2	3	3	1	2	2	1	2	2
CO5	*Understand the concepts of energy efficient devices.*	2	2	3	3	3	1	2	3	1	2	2

18PEE34	SPECIAL ELECTRICAL MACHINES AND DRIVES	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To review the fundamental concepts of permanent magnets and the operation of permanent magnet brushless DC motors.
2.	To introduce the concepts of permanent magnet brushless synchronous motors and Synchronous reluctance motors.
3.	To develop the control methods and operating principles of switched reluctance motors.
4.	To introduce the concepts of stepper motors and its applications.
5.	To understand the basic concepts of other special machines.

UNIT I	PERMANENT MAGNET BRUSHLESS DC MOTORS	9	+	0

Fundamentals of permanent magnets – Types – Principle of operation – Magnetic circuit analysis – EMF and Torque equations – Characteristics and control.

UNIT II	PERMANENT MAGNET SYNCHRONOUS MOTORS	9	+	0

Principle of operation – EMF and Torque equations – Phasor diagram – Power controllers – Torque-speed characteristics – Digital controllers – Constructional features, operating principle and characteristics of synchronous reluctance motor.

UNIT III	SWITCHED RELUCTANCE MOTORS	9	+	0

Constructional features – Principle of operation – Torque prediction – Characteristics – Power controllers – Control of SRM drive – Sensorless operation of SRM – Applications.

UNIT IV	STEPPER MOTORS	9	+	0

Constructional features –Principle of operation – Types – Torque predictions – Linear and Non-linear analysis – Characteristics – Drive circuits – Closed loop control – Applications.

UNIT V	OTHER SPECIAL MACHINES	9	+	0

Principle of operation and characteristics of Hysteresis motor – AC series motors – Linear induction motor – Applications.

Total (L+T)= 45 Periods

Course Outcomes:

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

CO1	*:*	*Gain the knowledge of fundamental concepts of special machines.*
CO2	*:*	*Develop the phasor diagram of Permanent Magnet Synchronous Motor.*
CO3	*:*	*Analyze and design controllers for special Electrical Machines.*
CO4	*:*	*Learn about characteristics and application of stepper motors.*
CO5	*:*	*Understand the necessity of special electrical machines in industry*

Text Books:

1.	Miller, T.J.E., “Brushless Magnet and Reluctance Motor Drives”, Claredon Press, London, 1989.
2.	Krishnan, R., ‘”Switched Reluctance Motor Drives”, CRC press, 2001.
3.	Kenjo, T., “Stepping Motors and their Microprocessor Controls’, Oxford University Press, New Delhi, 2000.

Reference Books:

1.	Kenjo, T & Nagamori, S., “Permanent Magnet and Brushless DC Motors’, Clarendon Press, London, 1988.
2.	Krishnan, R., “Electric Motor Drives”, Prentice Hall of India, 2002.

PO / CO	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	*Gain the knowledge of fundamental concepts of special machines.*	1	1	1	1	1	1	3	1	1	1	1
CO2	*Develop the phasor diagram of Permanent Magnet Synchronous Motor.*	1	2	2	3	1	2	2	1		2	1
CO3	*Analyze and design controllers for special Electrical Machines.*	1	2	2	2	2	1	1	1	1	3	1
CO4	*Learn about characteristics and application of stepper motors.*	2	3	2	3	3	1	2	2	1	2	2
CO5	*Understand the necessity of special electrical machines in industry*	2	2	3	3	3	1	2	3	1	2	2

18PEE35	DIGITAL SIMULATION OF POWER ELECTRONICS SYSTEM	L	T	P	C
		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

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

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

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

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

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

Course Outcomes:

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

CO1	:	*Understand the concepts of modeling and simulation of power electronics and drives circuits.*
CO2	:	*Develop algorithm and software models for power electronics and drives applications*
CO3	:	*Aanalyze the transient and steady performance of the designed models.*
CO4	:	*Choose suitable devices or models for appropriate applications*
CO5	:	*Identify suitable hardware components for implementation*

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.

PO / CO	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	*Understand the concepts of modeling and simulation of power electronics and drives circuits.*	3	2	2	2	2	1	2	1	2	1	1
CO2	*Develop algorithm and software models for power electronics and drives applications*	3	3	3	3	3	3	2	2	2	1	1
CO3	*Aanalyze the transient and steady performance of the designed models.*	3	3	3	2	2	2	3	3	2	1	1
CO4	*Choose suitable devices or models for appropriate applications*	3	3	2	3	3	2	2	2	1	2	1
CO5	*Identify suitable hardware components for implementation*	3	2	2	2	2	1	2	1	2	1	1

18PEE41	PHOTO VOLTAIC SYSTEM	L	T	P	C
		3	0	0	3

Course Objectives:

1.	Understand the principle of direct solar energy conversion to power using PV technology.
2.	Familiarize with the structure, materials and operation of solar cells, PV modules, and arrays.
3.	Understand The concept to design PV systems for various applications.
4.	Gain Knowledge on Socio-economic and environmental merits of photovoltaic systems for a variety of applications.

Unit I	PHOTOVOLTAIC CELL FUNDAMENTALS AND MANUFACTURING	9	+	0

Photovoltaic effect - Principle of direct solar energy conversion into electricity in a solar cell. Semiconductor properties, energy levels, basic equations. Solar cell, p-n junction, structure. Commercial solar cells - Production process of single crystalline silicon cells, multi crystalline silicon cells, amorphous silicon, cadmium telluride, copper indium gallium diselenide cells.

Unit II	PV MODULE PERFORMANCE	9	+	0

I-V characteristics of a PV module, maximum power point, cell efficiency, fill factor, effect of irradiation and temperature, casestudy

Unit III	DESIGN OF PV SYSTEMS	9	+	0

Design of solar PV systems and cost estimation. Case study of design of solar PV lantern, stand alone PV system - Home lighting and other appliances, solar water pumping systems.

Unit IV	CLASSIFICATION OF PV SYSTEMS AND COMPONENTS	9	+	0

Classification - Central Power Station System, Distributed PV System, Stand alone PV system, Grid Interactive PV System, small system for consumer applications, Hybrid solar PV system, Concentrator solar photovoltaic. System components - PV arrays, inverters, batteries, charge controls, net power meters. PV array installation, operation, costs, reliability.

Unit V	PV SYSTEM APPLICATIONS	9	+	0

Building-integrated photovoltaic units, grid-interacting central power stations, standalone devices for distributed power supply in remote and rural areas, solar cars, aircraft, space solar power satellites. Socio-economic and environmental merits of photovoltaic systems.

Total (L+T)= 45 Periods

Course Outcomes:

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

CO1	:	*Remember with the fundamental concepts of Solar Photovoltaic system*
CO2	:	*Understand the working operation of various components of photovoltaic system*
CO3	:	*Apply the relevant design concepts in any organisation*
CO4	:	*Analyze the performance of different PV system.*
CO5	:	*Evaluate and suggest the economic practices to be carried out for different applications.*

Reference Books:

1.	Chetan Singh Solanki : Solar photovoltaics: Fundamentals Technology and Applications, Second Edition, PHI, 2012
2.	Fundamentals of Photovoltaic Modules & Their Applications, by Gopal Nath Tiwari, ISBN:9781849730204, Publisher: Royal Society of Chemistry, 2010
3.	Photovoltaic Systems, 2nd Edition, by James P. Dunlop, ISBN:9780826913081, Publisher:American Technical Publishers, Inc. 2010
4.	Jha .A.R, “Solar Cell Technology and Applications”, CRC Press, 2010.

PO / CO	CO Statement	PO1	PO 2	PO 3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO1 1
CO1	*Remember with the fundamental concepts of Solar Photovoltaic system*	1	1	1	1	1	2	3	1	1	1	2
CO2	*Understand the working operation of various components of photovoltaic system*	1	1	2	2	2	1	1	1	1	3	1
CO3	*Apply the relevant design concepts in any organisation*	1	1	3	3	1	1	3	1	1	2	1
CO4	*Analyze the performance of different PV system.*	2	3	2	3	3	1	2	2	1	2	2
CO5	*Evaluate and suggest the economic practices to be carried out for different applications.*	2	2	3	3	3	3	2	3	2	2	2

18PEE42	OPTIMIZATION TECHNIQUES	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To understand the need for optimization and different techniques involved and also constraints.
2.	To know Linear/Non-linear Programming.
3.	To understand the importance of optimization to solve Engineering problems
4.	To know genetic algorithm for Engineering Optimization

Unit I	INTRODUCTION	9	+	0

Concepts of optimization- Engineering applications - Statement of optimization Problem -Classification - Classical Optimization Techniques: Single and multi variable optimization- Optimization with equality and inequality constraints

Unit II	LINEAR PROGRAMMING	9	+	0

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	NONLINEAR PROGRAMMING:	9	+	0

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

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

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 (L+T)= 45 Periods

Course Outcomes:

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

CO1	*:*	*Understand the basics of optimization*
CO2	*:*	*Design and formulate Linear Programming optimization problems*
CO3	*:*	*Design and formulate unconstraint and constraint optimization problems*
CO4	*:*	*Apply optimization problems to engineering applications*
CO5	*:*	*Analyze the optimization problems using Genetic Algorithm*

Text Books:

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.	G.Luenberger,- Introduction of Linear and Non-Linear Programming" , Wesley Publishing Company, 2011.

Reference Books:

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

PO / CO	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	*Understand the basics of optimization*	1	1	1	1	2	3	1	1	1	1	1
CO2	*Design and formulate Linear Programming optimization problems*	1	1	3	3	2	3	1	2	1	2	1
CO3	*Design and formulate unconstraint and constraint optimization problems*	1	1	3	3	3	3	3	2	1	2	1
CO4	*Apply optimization problems to engineering applications*	1	2	3	3	3	3	3	2	1	2	1
CO5	*Analyze the optimization problems using Genetic Algorithm*	1	2	3	3	3	3	3	3	1	2	1

18PEE43	POWER SYSTEM OPTIMIZATION TECHNIQUES	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To understand the need for optimization and different techniques involved and also constraints.
2.	To know evolutionary computation techniques
3.	To understand the importance of particle swarm optimization in power system
4.	To know advanced and multi objective Optimization

Unit I	FUNDAMENTALS OF OPTIMIZATION	9	+	0

Definition-Classification of optimization problems-Unconstrained and Constrained optimization-Optimality conditions-Classical Optimization techniques-Linear and non linear programming, Quadratic programming, Mixed integer programming

Unit II	EVOLUTIONARY COMPUTATION TECHNIQUES	9	+	0

Evolution in nature-Fundamentals of Evolutionary algorithms-Working Principles of Genetic Algorithm-Evolutionary Strategy and Evolutionary Programming-Genetic Operators-Selection, Crossover and Mutation-Issues in GA implementation- GA based Economic Dispatch solution- GA for unit commitment-GA based Optimal power flow- GA based state estimation

Unit III	PARTICLE SWARM OPTIMIZATION	9	+	0

Fundamental principle-Velocity Updating-Advanced operators-Parameter selection- Hybrid approaches (Hybrid of GA and PSO, Hybrid of EP and PSO) -Binary, discrete and combinatorial PSO-Implementation issues -Convergence issues- PSO based unit commitment-PSO for reactive power and voltage control-PSO for power system reliability and security.

Unit IV	ADVANCED OPTIMIZATION METHODS	9	+	0

Simulated annealing algorithm-Tabu search algorithm-SA and TS for unit commitment-Ant colony optimization- Bacteria Foraging optimization.

Unit V	MULTI OBJECTIVE OPTIMIZATION	9	+	0

Concept of pareto optimality-Conventional approaches for multi objective optimization -Multi objective GA-Fitness assignment-Sharing function-Economic dispatch using multi objective GA-Multiobjective PSO.

Total (L+T)= 45 Periods

Course Outcomes:

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

CO1	*:*	*Understand the basics of optimization*
CO2	*:*	*To understand the need of optimization in power system*
CO3	*:*	*Design and formulate power system optimization problems using GA and PSO*
CO4	*:*	*Understand the basics of advanced optimization techniques.*
CO5	*:*	*Analyze the optimization problems using multi objective Genetic Algorithm*

Text Books:

1.	D.P.Kothari and J.S.Dhillon, “Power System Optimization”, 2nd Edition, PHI learning private limited, 2010.
2.	Jizhong Zhu,”Optimization of power system operation”,John Wiley and sons Inc publication,2009.
3.	SolimanAbdel Hady,Abdel Aal Hassan Mantawy, “Modern optimization techniques with applications in Electric Power Systems”, Springer,2012.
4.	Kalyanmoy Deb, “Multi objective optimization using Evolutionary Algorithms”, John Wiley and Sons, 2008.

Reference Books:

1.	Kalyanamoy Deb, “Optimization for Engineering design algorithms and Examples”, Prentice Hall of India Pvt. 1995.
2.	Carlos A.Coello Coello, Gary B.Lamont, David A.Van Veldhuizen, “Evolutionary Algorithms for solving Multi Objective Problems”, 2nd Edition, Springer, 2007.

PO / CO	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	*Understand the basics of optimization*	1	1	1	1	2	3	1	1	1	1	1
CO2	*To understand the need of optimization in power system*	1	1	2	2	2	3	1	1	1	2	1
CO3	*Design and formulate power system optimization problems using GA and PSO*	1	1	3	3	3	3	3	3	1	2	1
CO4	*Understand the basics of advanced optimization techniques.*	1	1	2	2	3	3	2	2	1	2	1
CO5	*Analyze the optimization problems using multi objective Genetic Algorithm*	1	2	3	3	3	3	2	3	1	2	1

18PEE44	WIND ENERGY SYSTEM	L	T	P	C
		3	0	0	3

Course Objectives:

1. To impart understanding of various aspects related to wind energy systems and technology.

Unit I	Wind Energy Fundamentals	9	+	0

Wind Energy Program in India and the World: Overview of growth, development, progress and challenges facing the wind industry.

Wind Energy Basics, Wind resource assessment, Wind Speeds and scales, Terrain, Roughness, Wind Mechanics, Power Content, Principles of Aerodynamics of wind turbine blade, Class of wind turbines, Atmospheric Boundary Layers, Turbulence.

Unit II	Wind Measurements, Analysis and Energy Estimates & Aerodynamics Theory	9	+	0

Instrumentation for wind measurements, Wind data analysis, Wind resource estimation, Betz's Limit, Turbulence Analysis

Airfoil terminology, Blade element theory, Blade design, Rotor performance and dynamics, Balancing technique (Rotor & Blade), Types of loads; Sources of loads

Unit III	Wind Turbine Technology & Components of Wind Turbine Generator	9	+	0

HAWT and VAWT, Constant Speed Constant Frequency, Variable speed Variable Frequency, Up Wind, Down Wind, Stall Control , Pitch Control, Gear Coupled Generator type, Direct Generator Drive /PMG/Rotor Excited Sync Generator.

Gear Coupled Generator Wind Turbine Components and their construction, Direct Rotor Coupled Generator (Multipole type)

Unit IV	Modern Wind Turbine Control & Monitoring System	9	+	0

Details of Pitch System & Control Algorithms, Protections used & Safety Consideration in Wind turbines, Wind Turbine Monitoring with Error codes, SCADA & Databases: Remote Monitoring and Generation Reports, Operation & Maintenance for Product Life Cycle, Balancing technique (Rotor & Blade), FACTS control, Low Voltage Ride-Through & new trends for new grid codes.

Unit V	Wind Farms & Cost Economics	9	+	0

Typical layouts, site selection of wind farms, power evacuation, and operational problems with grid interface. Offshore and onshore wind farms, merits and challenges.

Wind resource assessment and R & D costs, Fixed and variable costs, Value of wind energy, Life cycle costing and cash flow of wind power projects, Wind project owners / developers, Wind energy market

Total (L+T)= 45 Periods

COURSE OUTCOMES:

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

CO1	:	*Apply the concepts of wind energy sources for electricity generation*
CO2	:	*Evaluate and analyse the options and estimate the wind energy generation through renewable sources*
CO3	:	*Understand the concepts and components of wind energy systems.*
CO4	:	*Understand the modern wind turbine control & monitoring system and evaluate the control algorithms*
CO5	:	*Evaluate and analyse the wind resource assessment and R & D costs*

Reference Books

1.	Golding E. W., "The Generation of Electricity by Wind farms", E & F.N. Spon Ltd, London.(U.K).
2.	Johnson, Gary, L. " Wind Energy System " , Prentice Hall Inc . Englewood Cliffs. N.J. (USA)
3.	Freris, L.L." Wind Energy Conversion System" Prentice Hall,(U.K.)
4.	Heier, S,"Grid Integration of Wind Energy Conversion Systems". Wiley,New York (USA)
5.	Anna Mani, D. A. Mooley, "Wind Energy Data for India"
6.	C-WET Wind Energy Resources Survey in India VI
7.	Sathyajith Mathew, "Wind Energy : Fundamentals, Resource Analysis and Economics", Springer Science & Business Media, March 2006
8.	B.H. Khan," Non-Conventional Energy Resources", Tata Mc.Graw Hill Edu Pvt. Ltd.

PO / CO	CO Statement	PO1	PO 2	PO 3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO1 1
CO1	*Apply the concepts of wind energy sources for electricity generation*	3	1	1	1	1	1	1	1	1	1	1
CO2	*Evaluate and analyse the options and estimate the wind energy generation through renewable sources*	1	3	2	1	2	1	1	1	1	1	1
CO3	*Understand the concepts and components of wind energy systems.*	2	1	1	3	1	1	1	1	1	1	1
CO4	*Understand the modern wind turbine control & monitoring system and evaluate the control algorithms*	1	1	1	2	3	1	2	1	1	1	1
CO5	*Evaluate and analyse the wind resource assessment and cost economics.*	1	1	3	2	1	1	1	1	1	1	1

18PEE45	POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEM	L	T	P	C
		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

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

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

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

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

Generic structure for grid connected PV system- Single stage grid connected PV system-Control scheme- Grid Synchronization Techniques for Single-Phase Systems- Grid Synchronization Using a Phase-Locked Loop-Control structure of WES- Generator Side Control- WES Grid Control-Influence of active and reactive power injection by WES.

Total (45+0)= 45 Periods

Course Outcomes:

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

CO1	:	*Know solar, fuel cell and wind energy conversion principles.*
CO2	:	*Select suitable power inverters for green energy systems.*
CO3	:	*Design wind and solar based power plants.*
CO4	:	*Design an appropriate system for standalone and grid connected operation.*
CO5		*Know grid integration challenges with fuel cell, solar and wind energy systems.*

Text Books:

1.	Chetan Singh Solanki, " Solar Photovoltaics: Fundamentals, Technologies and Applications", PHI Learning Private Limited, New Delhi, 2011.
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.

PO / CO	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	*Know solar, fuel cell and wind energy conversion principles.*		1			1	3			1	2	
CO2	*Select suitable power inverters for green energy systems.*	2	3								1	
CO3	*Design wind and solar based power plants.*			2	1			1	2			1
CO4	*Design an appropriate system for standalone and grid connected operation.*			2				1	2			1
CO5	*Know grid integration challenges with fuel cell, solar and wind energy systems.*			1	2					1		

18PEE51	SMART GRID TECHNOLOGY	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To introduce the concepts of Smart Grid, architecture and Functions.
2.	To familiarize the role of communications technologies in Smart Grid.
3.	To familiarize control and automation technologies for Smart Grid.
4.	To study the green energy integration and energy storage systems.

Unit I	INTRODUCTION TO SMART GRID	9	+	0

Definitions and Need for Smart Grid, Today's Electric Grid versus Smart Grid, key aspects of Smart Grid development, Smart Grid architecture, Functions of Smart Grid Components, challenges and benefits.

Unit II	COMMUNICATIONS TECHNOLOGIES	9	+	0

Communication infrastructure for the Smart Grid, IEEE 802 architecture and, communication technologies specified under IEEE 802, Wireless LANs, ZigBee and 6LoWPAN, ZigBee communication network for smart metering, Power line communication, Standards for smart metering, Modbus, DNP3, IEC 61850 data structure and usage.

Unit III	CONTROL AND AUTOMATION TECHNOLOGIES	9	+	0

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	9	+	0

Need for energy storage in smart grid, Energy storage technologies: operation, features and use of Flow battery, Fuel cell, Superconducting magnetic energy storage systems, Super capacitors; power converter configurations for energy storage integration, Energy storage system for solar and wind power plant-case study.

Unit V	GREEN ENERGY INTEGRATION	9	+	0

Sustainable energy options for the smart grid- Solar PV System, Wind Energy and Fuel Cell: Conversion and Power electronics technology for grid integration, Penetration and variability issues associated with sustainable energy technology, PHEV technology, Impact of PHEV on the Smart Grid.

Total (45+0) = 45 Periods

Course Outcomes:

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

CO1	:	*Understand the concepts of Smart Grid and its present developments.*
CO2	:	*Get acquainted with the smart resources and other smart devices*
CO3	:	*Acquire knowledge of automation and control infrastructure.*
CO4	:	*Select an energy storage system and its integration with Smart Grids*
CO5	:	*Identify suitable communication networks for smart grid applications*

Text Books:

1.	James Momoh "SMART GRID Fundamentals of Design and Analysis", Wiley, 2012.
2.	Janaka Ekanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, "SmartGrid: Technology and Applications", Wiley, 2012.
3.	Mini S. Thomas, John D McDonald, 'Power System SCADA and Smart Grids', CRC Press, 2015

PO CO	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	*Understand the concepts of Smart Grid and its present developments.*			1		1	1	2			3	
CO2	*Get acquainted with the smart resources and other smart devices*	1							2	1		
CO3	*Acquire knowledge of automation and control infrastructure.*		1									1
CO4	*Select an energy storage system and its integration with Smart Grids*	3	1		1							
CO5	*Identify suitable communication networks for smart grid applications*				1		1				2	

18PEE52	DISTRIBUTED GENERATION	L	T	P	C
		3	0	0	3

Course Objectives:

1.	*To illustrate the concept of distributed generation.*
2.	*To familiarize with the integration of DG in distribution systems*

Unit I	INTRODUCTION	9	+	0

Conventional power generation: advantages and disadvantages, Energy crises, Nonconventionalenergy (NCE) resources: review of Solar PV, Wind Energy systems, Fuel Cells, micro-turbines, biomass, cogenerationand tidal sources.

Unit II	DISTRIBUTED GENERATION	9	+	0

Concept of Distributed Generations (DGs), 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	DISTRIBUTED GENERATION PLANNING AND EVALUATION	9	+	0

Planning of DGs – Types of DG Planning Methods - Sitting and Sizing of DGs Optimal Placement of DG Sources in Distribution Systems. Technical impacts of DGs - Computer Aided Sizing and Sitting of DGs for Network Loss Minimisation and Voltage Profile Improvement. Economic and Control Aspects of DGs Market facts. DG Evaluation -Basic Cost Analysis – Cost Evaluation and Schedule of Demand – Modelling Uncertain Costs – Sensitivity Studies on Key Factors.

Unit IV	IMPACT OF GRID INTEGRATION	9	+	0

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 V	DISTRIBUTED POWER GENERATION SYSTEM AND PROTECTION	9	+	0

Introduction – Configurations of Typical Distributed Power Generation Systems (DPGS)– Wind DPGs and PV DPGs. Resilience-relevant demands and control strategies -Tolerance of Frequency and Voltage Deviations , Frequency and Voltage Regulation, Unintentional Islanding Extreme Climate Disaster and Restoration.DPGS Protection - Protection Issues in DPGS - DPGS Protection to Improve Resilience.

Total (L+T)=45 Periods

Course Outcomes:

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

CO1	:	*Understand the concept of distributed generation and topologies.*
CO2	:	*Analyse the size and location of distributed generation.*
CO3	:	*Analyse the impact of DGs in distribution system and challenges in grid integration.*
CO4	:	*Understand the distributed power generation protection schemes*
CO5	:	*Analyse the planning and operational issues related to distributed generation.*

Reference Books:

1.	*Distributed Power Generation – Planning and Evaluation, H. Lee Willis & Walter G. Scott,CRC Press.*
2.	*Handbook of Distributed Generation- Electric Power Technologies, Economics and Environmental Impacts, Ramesh Bansal, Springer.*
3.	*Distributed Generation Systems Design, Operation and Grid Integration, G.B.Gharehpetian&S.Mohammad Mousavi Agah, Elsevier.*
4.	*Distributed Power-Generation Systems and Protection, FredeBlaabjerg, Yongheng Yang, Dongsheng Yang &Xiongfei Wang, Proceedings of the IEEE, Vol. 105, No. 7, pp. 1311-1331, July 2017.*
5.	*Optimal Distributed Generation Placement in Power Distribution Networks: Models, Methods, and Future Research, Georgilakis, Pavlos& Nikos D. Hatziargyriou, IEEE Transactions on Power Systems, Vol. 28, No. 3, pp. 3420-3428, 2013.*
6.	*Integration of Distributed Generation in the Volt/VAR Management System for Active Distribution Networks, Barr, Johanna&Ritwik Majumder, IEEE Transactions on Smart Grid, Vol. 6, No. 2, pp. 576-586, 2015.*

PO / CO	CO Statement	PO1	PO 2	PO 3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO1 1
CO1	*Understand the concept of distributed generation and topologies.*	3	1	2	1	1	1	3	1	1	1	1
CO2	*Analyse the size and location of distributed generation.*	2	3	3	3	2	2	3	2	1	2	2
CO3	*Analyse the impact of DGs in distribution system and challenges in grid integration.*	2	3	3	2	3	2	2	2	1	3	2
CO4	*Understand the distributed power generation protection schemes*	3	2	2	1	2	2	2	1	1	1	1
CO5	*Analyse the planning and operational issues related to distributed generation.*	2	3	3	3	3	3	2	1	1	3	2

18PEE53	FACTS CONTROLLERS	L	T	P	C
		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 understand the principle of operation of UPFC and IPFC.
4.	To understand the concept of coordination of FACTS controllers.

Unit I	FACTS CONCEPTS	9	+	0

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

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

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

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

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 (L+T)= 45 Periods

Course Outcomes:

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

CO1	*:*	*Remember knowledge about reactive power flow control in power systems.*
CO2	*:*	*Understand various static series and shunt compensation techniques.*
CO3	*:*	*Analyze the structure and principle of operation of FACTS devices.*
CO4	*:*	*Apply the FACTS devices at suitable location in power system networks.*
CO5	*:*	*Understand the co-ordination of FACTS controllers.*

Text Books:

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.

Reference Books:

1.	X.P. Zhang, C. Rehtanz, B. Pal, “Flexible AC Transmission Systems- Modelling and Control”, Springer Verlag, Berlin, 2006.
2.	R. Mohan Mathur, Rajiv K Verma, “Thyrisor-Based FACTS Controllers for Electrical Transmission Systems”, IEEE press, Wiley-Interscience Publications, 2002.

PO / CO	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	*Remember knowledge about reactive power flow control in power systems.*	2	3	1	1	1	1	3	1	2	1	1
CO2	*Understand various static series and shunt compensation techniques.*	2	1	3	3	1	1	3	1	1	2	1
CO3	*Analyze the structure and principle of operation of FACTS devices.*	1	1	2	2	2	3	1	1	1	3	1
CO4	*Apply the FACTS devices at suitable location in power system networks.*	2	3	2	3	3	1	2	2	1	2	2
CO5	*Understand the co-ordination of FACTS controllers.*	2	1	3	2	1	1	2	3	1	2	1

18PEE54	HVDC TRANSMISSION SYSTEMS	L	T	P	C
		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

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

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

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

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

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 (L+T)= 45Periods

Course Outcomes:

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

CO1	:	*Understand the concept of HVDC technology*
CO2	:	*Explain the basic concepts of HVDC and MTDC systems.*
CO3	:	*Analyze and control six-pulse and multiple-bridge converters*
CO4	:	*Design of harmonics filters.*
CO5	:	*Work with the modelling of HVDC systems*
CO6	:	*Apply simulation tools for HVDC system*

Text Books:

1.	Padiyar, K.R., “HVDC Power Transmission Systems”, New Age International Publishers, New Delhi, 2010.
2.	Arrillaga, J., “HVDC Transmission”, Peter Peregrinus, London, 1983.

Reference Books:

1.	Colin Adamson and N.G.Hingorani, “High Voltage Direct current Power Transmission”, Garraway Limited, London, First edition, 1960.
2.	Edward Wilson Kimbark, “Direct Current Transmission”, Vol.I, Wiley Interscience, New York, 1971.
3.	Erich Uhlmann, “Power Transmission by Direct Current”, B.S. Publications, 2004.
4.	Kamakshaiah, S. & Kamaraju, V, “HVDC Transmission”, 1st Edition, Tata McGraw Hill, 2011.

PO / CO	**CO Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**
CO1	*Understand the concept of HVDC technology*	3	1	2	3	2	1				2	1
CO2	*Explain the basic concepts of HVDC and MTDC systems.*	3	2	3	3	1	1	1	1	1	2	1
CO3	*Analyze and control six-pulse and multiple-bridge converters*	3	2	3	1	1					1	
CO4	*Design of harmonics filters*	2	2	3	3	2	1	1	1	1	2	1
CO5	*Work with the modelling of HVDC systems*	2	3	2	2	1	1	2	1	1	1	1
CO6	*Apply simulation tools for HVDC system*	1	2	2	3	3	1	2	1	1	2	2

18PEE55	SCADA SYSTEMS AND APPLICATIONS	L	T	P	C
		3	0	0	3

Course Objectives:

1.	*To understand about the SCADA system components and SCADA communication protocols.*
2.	*To provide knowledge about SCADA applications in power system.*

Unit I	INTRODUCTION TO SCADA	9	+	0

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

Unit II	SCADA SYSTEM COMPONENTS	9	+	0

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.

Unit III	SCADA COMMUNICATION	9	+	0

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.

Unit IV	MONITORING AND CONTROL	9	+	0

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.

Unit V	SCADA APPLICATIONS	9	+	0

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 (L+T)= 45 Periods

Course Outcomes:

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

CO1	*:*	*Describe the basic tasks of Supervisory Control Systems (SCADA) as well as their typical applications.*
CO2	*:*	*Acquire knowledge about SCADA architecture, various advantages and disadvantages of each system.*
CO3	*:*	*Knowledge about single unified standard architecture IEC 61850.*
CO4	*:*	*To learn about SCADA system components: remote terminal units, PLCs, intelligent electronic devices, HMI systems.*
CO5	*:*	*Learn and understand about SCADA applications in transmission and distribution sector,industries etc.*

Reference Books:

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

PO / CO	CO Statement	PO1	PO 2	PO 3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO1 1
CO1	*Describe the basic tasks of Supervisory Control Systems (SCADA) as well as their typical applications.*	1	1	1	1	1	1	3	1	1	1	1
CO2	*Acquire knowledge about SCADA architecture, various advantages and disadvantages of each system.*	1	1	3	3	1	1	3	1	1	2	1
CO3	*Knowledge about single unified standard architecture IEC 61850.*	1	1	2	2	2	1	1	1	1	3	1
CO4	*To learn about SCADA system components: remote terminal units, PLCs, intelligent electronic devices, HMI systems.*	2	3	2	3	3	1	2	2	1	2	2
CO5	*Learn and understand about SCADA applications in transmission and distribution sector,industries etc.*	2	2	3	3	3	1	2	3	1	2	2

18PEE61	ELECTRICAL VEHICLES	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To understand the concept of electrical vehicles and its operations
2.	To understand the need for energy storage in hybrid vehicles
3.	To provide knowledge about various possible energy storage technologies that can be Used in electric vehicles

Unit I	INTRODUCTION	9	+	0

Electric Vehicles (EV), Hybrid Electric Vehicles (HEV), Engine ratings, Comparisons of EV with internal combustion Engine vehicles, Fundamentals of vehicle mechanics.

Unit II	ARCHITECTURE	9	+	0

Architecture of EV's and HEV's – Plug-n Hybrid Electric Vehicles (PHEV) - Power train components and sizing, Gears, Clutches, Transmission and Brakes.

Unit III	DRIVES	9	+	0

DC/DC chopper based four quadrant operations of DC drives – Inverter based V/f Operation (motoring and braking) of induction motor drive system – Induction motor and permanent motor based vector control operation – Switched reluctance motor (SRM) drives.

Unit IV	BATTERIES	9	+	0

Battery Basics, Different types, Battery Parameters, Battery modeling, Traction Batteries

Unit V	FUEL CELL	9	+	0

Fuel cell – Characteristics- Types – hydrogen Storage Systems and Fuel cell EV – Ultra capacitors

Total (L+T)= 45 Periods

Course Outcomes:

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

CO1	:	*Remember the fundamentals of electric vehicle and its mechanics*
CO2	:	*Understand the architecture of electric and hybrid electric vehicle.*
CO3	:	*Analyse the four quandrant operation of DC drive, induction motor drive and SRM drive.*
CO4	:	*Apply and analyse the basic battery concepts and modeling.*
CO5	:	*Understand the concepts of fuel cell*

Reference Books:

1.	"Electric and Hybrid Vehicles: Design Fundamentals",Iqbal Hussain, CRC Press, Taylor & Francis Group, Second Edition (2011).
2.	"Vehicular Electric Power Systems", Ali Emadi, Mehrdad Ehsani, John M.Miller, Special Indian Edition, Marcel dekker, Inc 2010

PO / CO	CO Statement	PO1	PO 2	PO 3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO1 1
CO1	*Remember the fundamentals of electric vehicle and its mechanics*	3	1	2	1	1		1	1		1	1
CO2	*Understand the architecture of electric and hybrid electric vehicle.*	1	1	3	2	2		2			2	
CO3	*Analyse the four quandrant operation of DC drive, induction motor drive and SRM drive.*	1	1	2	3	2		1	1	1	3	
CO4	*Apply and analyse the basic battery concepts and modeling.*	2	3	3	1	1		1	2		1	2
CO5	*Understand the concepts of fuel cell*	2	1	1	1	2		1	3		1	1

18PEE62	THEORY AND DESIGN OF SMPS	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To know operation and design procedure.
2.	To analyze and design control techniques
3.	To design required magnetics for converters
4.	To select proper components and scheme protection circuits

Unit I	DESIGN OF NON-ISOLATED DC-DC CONVERTERS	9	+	0

Topologies, General Design Method, Design of Buck Converter, Boost Converter, Buck/Boost Converter, Charge Pumps

Unit II	DESIGN OF ISOLATED DC-DC CONVERTERS	9	+	0

Design of Fly-back Converter, Forward Converter, Push-Pull Converter, Half Bridge and Full Bridge Converters

Unit III	CONTROL CIRCUITS	9	+	0

Basic Control Circuits, Error Amplifier and its compensation, Voltage mode Control, Current Mode Control, Compensated Mode Control, Voltage feed-back circuit, IC Control Module, Typical PWM Control Module, TL494, SG1524

Unit IV	DESIGN OF MAGNETIC ELEMENTS	9	+	0

Magnetic Concepts, Inductor design, Transformer Design for Fly-back, Forward and Push-Pull converters

Unit V	SELECTION OF PERIPHERAL COMPONENTS	9	+	0

Fixed Resistor, Capacitors, EMI Filter, Input and Output rectifier, Voltage suppressors, Opto-coupler, Power Switches, Protection elements

Total (L+T)= 45 Periods

Course Outcomes:

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

CO1	*:*	*Implement design concepts and analyze the converters*
CO2	*:*	*Select the appropriate control strategy and implement*
CO3	*:*	*Select the appropriate power devices*
CO4	*:*	*Design the magnetic components based on requirements*
CO5	*:*	*Select the components to meet the complete realization of converter and Choose the correct protection and filter elements*

Reference Books:

1.	Marty Brown et. al - Power Sources and Supplies World Class Designs, Newnes 2007
2.	Marty Brown – Power Supply Cook Book 2nd, Newnes 2001
3.	Umanand – Power Electronics Essentilas and Applications – Wiley 2009
4.	Zhanyou et. al – Optimal Design of Switching Power Supply – Wiley 2015
5.	Branko et. al. – Power Electronics Converters and Regulators, 3rd Edition – Springer

Online Resources

1.	Umanand and Ramanarayanan - Switched Mode Power Conversion, NPTEL https://nptel.ac.in/syllabus/108108036/

PO / CO	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	*Implement design concepts and analyze the converters*	1	1	1	1	1						1
CO2	*Select the appropriate control strategy and implement*	1	1	2	2	1			1			1
CO3	*Select the appropriate power devices*	1	2	1	1	1			1			1
CO4	*Design the magnetic components based on requirements*	1	2	2	2	1			2			1
CO5	*Select the components to meet the complete realization of converter and Choose the correct protection and filter elements*	1	2	2	1	1			1		2	1

18PEE63	ENERGY STORAGE TECHNOLOGY	L	T	P	C
		3	0	0	3

Course Objectives:

To explore the fundamentals, technologies and applications of energy storage

Unit I	STORAGE: HISTORICAL PERSPECTIVE, INTRODUCTION AND CHANGES	9	+	0

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

Introduction: Energy and Energy Transformations, Potential energy (pumped hydro, compressed air, springs)- Kinetic energy (mechanical flywheels)- Thermal energy without phase change passive (adobe) and active (water)-Thermal energy with phase change (ice, molten salts, steam)- Chemical energy (hydrogen, methane, gasoline, coal, oil)- Electrochemical energy (batteries, fuel cells)- Electrostatic energy (capacitors), Electromagnetic energy (superconducting magnets)- Different Types of Energy Storage Systems.

Unit III	PERFORMANCE FACTORS OF ENERGY STORAGE SYSTEMS	9	+	0

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

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

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

Total (L+T)= 45 Periods

Course Outcomes:

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

CO1	*:*	*Recollect the historical perspective and technical methods of energy storage.*
CO2	*:*	*Learn the basics of different storage methods.*
CO3	*:*	*Understand the concepts of energy conversion technology*
CO4	*:*	*Determine the performance factors of energy storage systems*
CO5	*:*	*Identify the applications of various energy storage systems*

Reference Books:

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 Electrochemical Society, New Jersy,2010*

PO CO	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	*Recollect the historical perspective and technical methods of energy storage.*	3	2	2	2	2	2	1	2	1	3	2
CO2	*Learn the basics of different storage methods.*	3	2	2	2	2	2	1	2	1	2	1
CO3	*Understand the concepts of energy conversion technology*	3	3	3	3	2	2	1	2	1	2	1
CO4	*Determine the performance factors of energy storage systems*	3	3	3	3	2	2	1	2	1	2	1
CO5	*Identify the applications of various energy storage systems*	3	3	3	3	2	2	1	2	1	2	1

18PEE64	INTERNET OF THINGS FOR ELECTRICAL ENGINEERS	L	T	P	C
		3	0	0	3

Course Objectives:

1.	*To illustrate the concept of Internet of Things (IoT).*
2.	*To familiarize with implementations of IoT for electrical engineering applications.*

Unit I	INTRODUCTION	9	+	0

Internet of Things - Physical Design- Logical Design- IoT Enabling Technologies - IoT Levels &Deployment Templates - Domain Specific IoTs - IoT and M2M - IoT System Management withNETCONF-YANG- IoT Platforms Design Methodology.

Unit II	ARCHITECTURE	9	+	0

M2M high-level ETSI architecture - IETF architecture for IoT - OGC architecture - IoT referencemodel - Domain model - information model - functional model - communication model – IoT reference architecture

Unit III	IOT PROTOCOLS	9	+	0

Protocol Standardization for IoT – Efforts – M2M and WSN Protocols – SCADA and RFIDProtocols – Unified Data Standards – Protocols – IEEE 802.15.4 – BACNet Protocol – Modbus–Zigbee Architecture – Network layer – 6LowPAN - CoAP - Security

Unit IV	BUILDING IOT	9	+	0

Building IOT with RASPERRY PI- IoT Systems - Logical Design using Python – IoT Physical Devices & Endpoints - IoT Device -Building blocks -Raspberry Pi -Board - Linux on Raspberry Pi - Raspberry Pi Interfaces -Programming Raspberry Pi with Python - Other IoT Platforms - Arduino.

Unit V	APPLICATIONS	9	+	0

Real world design constraints - Applications - Asset management, Industrial automation, smartgrid, Commercial building automation, Smart cities - participatory sensing - Data Analytics for IoT– Software & Management Tools for IoT Cloud Storage Models & Communication APIs – Cloud for IoT - Amazon Web Services for IoT.

Total (L+T)= 45 Periods

Course Outcomes:

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

CO1	:	*Analyze various protocols for IoT.*
CO2	:	*Develop web services to access/control IoT devices.*
CO3	:	*Design a portable IoT using Rasperry Pi.*
CO4	:	*Deploy an IoT application and connect to the cloud.*
CO5	:	*Analyze applications of IoT in real time scenario.*

References:

1.	*The Internet of Things – Enabling Technologies, Platforms, and Use Cases,Pethuru Raj & Anupama C. Raman,CRCPress.*
2.	*Internet of Things – A hands-on approach, ArshdeepBahga&Vijay Madisetti, Universities Press.*
3.	*From Machine-to-Machine to the Internet of Things - Introduction to a New Age of Intelligence, Jan Holler, VlasiosTsiatsis, Catherine Mulligan, Stamatis, Karnouskos, Stefan Aves & David Boyle, Elsevier.*
4.	*The Internet of Things – Key applications and Protocols, Olivier Hersent, David Boswarthick& Omar Elloumi, Wiley.*
5.	*The Internet of Things in the Cloud: A Middleware Perspective, Honbo Zhou, CRC Press.*
6.	*Integration of Distributed Generation in the Volt/VAR Management System for Active Distribution Networks, Barr, Johanna &RitwikMajumder, IEEE Transactions on Smart Grid, Vol. 6, No. 2, pp. 576-586, 2015.*
7.	*Review of Internet of Things (IoT) in Electric Power and Energy Systems, GuneetBedi, Ganesh Kumar Venayagamoorthy, Rajendra Singh, Richard Brooks &Kuang-Ching Wang, IEEE Internet of Things Journal, DOI 10.1109/JIOT.2018.2802704.*

PO / CO	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	*Analyze various protocols for IoT*	1	1	1	1	1	1	3	1	1	1	1
CO2	*Develop web services to access/control IoT devices.*	1	1	3	3	1	1	3	1	1	2	1
CO3	*Design a portable IoT using Rasperry Pi.*	1	1	2	2	2	1	1	1	1	3	1
CO4	*Deploy an IoT application and connect to the cloud.*	2	3	2	3	3	1	2	2	1	2	2
CO5	*Analyze applications of IoT in real time scenario.*	2	2	3	3	3	1	2	3	1	2	2

18PEE65	DIGITAL SIGNAL PROCESSORS FOR POWER CONVERTERS	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To understand the basic concepts of discrete time signals, digital signal processors, programming and applications.

Unit I	INTRODUCTION to TMS 320C54X PROCESSOR	9	+	0

Need for digital signal processor - Basic architecture of DSP's – Architecture of TMS 320C54X processors- Addressing modes- Assembly instructions- Pipelining- Interrupts- Clock generator- Timer- Serial ports- Parallel ports- Host-port interface (HPI)

Unit II	TMS 320C67X PROCESSOR	9	+	0

Architecture of TMS 320C67X processor- CPU data paths and control. Addressing modes. Instruction set. Pipeline operation.

Unit III	PERIPHERALS AND INTERFACE	9	+	0

Interfacing with serial I/O- A/D, D/A converters- Parallel interfacing- Interfacing with RAM- EEPROMs - Wait state generation.-DSP tools: Assembler- Debugger- C compiler- Linker -loader.

Unit IV	ADVANCES IN DSP PROCESSORS	9	+	0

VLIW Architecture – Multiprocessor DSPs, SHARC, SIMB, MIMD Architectures and Analog Devices DSPs – introduction to FPGA – FPGA based DSP system – Architecture of TMS 320F28335

Unit V	MOTOR CONTROL APPLICATION	9	+	0

DSP-Based Implementation of DC-DC Buck-Boost Converters - DSP-Based Control of Matrix Converters - DSP based Switched reluctance motor control- DSP based brushless DC motor control, DSP based control of Permanent Magnet Synchronous Motor

Total (45+0)= 45Periods

Course Outcomes:

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

CO1	*:*	*Understand the basic concepts of digital signal processor.*
CO2	*:*	*Program the digital signal processor.*
CO3	*:*	*Analyze interfacing of peripherals with DSP.*
CO4	*:*	*Understand the advancements in DSP processors*
CO5	*:*	*Programming of DSP for motor control.*

Text Books:

1.	B.Venkataramani et al. "Digital Signal processor –Architecture, Programming and Applications", TMH, New Delhi 2010, second edition.
2.	*S.Srinivasan & Avtar Singh, 'Digital Signal Processing, Implementations using DSP Microprocessors with Examples from TMS320C54X", Brooks/Cole, 2004.*
3.	Hamid A Joliyet and Steven G Campell, "DSP Based Electromechanical Motion Control" CRCPresss 2003.
4.	User guides Texas Instrumentation, Analog Devices, Motorola.
5.	*Sen M.Kuo & Woon-Seng S.Gan, Digital Signal Processors: Architectures, Implementations, and Applications, Printice Hall, 2004*

PO / CO	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	*Understand the basic concepts of digital signal processor.*	1	1	1	1	1	1	1	1	1	2	1
CO2	*Program the digital signal processor.*	1	1	1	1	1	1	3	3	1	2	1
CO3	*Analyze interfacing of peripherals with DSP.*	1	1	2	2	2	1	2	1	1	2	1
CO4	*Understand the advancements in DSP processors*	1	1	2	2	3	1	2	3	1	2	1
CO5	*Programming of DSP for motor control.*	2	3	3	3	3	1	3	3	1	2	1

18AC01	ENGLISH FOR RESEARCH PAPER WRITING	L	T	P	C
		2	0	0	0

Course Objectives:

To understand the importance of writing skills in a Research paper. To Learn how to write different sections in a research paper and skills of writing a good research paper

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

Research paper and its importance – Structure of a research paper – Planning and Preparation

Unit II	**4**	**+**	**0**

English in research papers – Basic word order – Collocation – Concord – Breaking up of long sentences – Ambiguity and Redundancy

Unit III	**4**	**+**	**0**

Key factors that determine the style of a paper – Journal's background – Passive form – Right tense – Cohesion and Coherence.

Unit IV	**4**	**+**	**0**

Highlighting you findings – Hedging and Criticizing – Paraphrasing and Plagiarism.

Unit V	**4**	**+**	**0**

Key skills in writing Title – Abstract – Introduction – Review of Literature – Methods – Discussion and Conclusion – useful phrases – Ensuring quality of the paper.

Total (L+T) = 20 periods

Course Outcomes:

1.	***Upon completion of the course, the students will be able to:*** *Understand and appreciate the process of writing a good research paper*
2.	*Apply their gained knowledge in writing a research paper*
3.	*Analyse and assess the quality of their research paper*

Suggested reading

1	Goldbort R (2006) **"Writing for Science,"** Yale University press
2	Day R (2006) **"How to Write and Publish a Scientific Paper,"** Cambridge University Press
3	Highman N (1998), **"Handbook of Writing for the Mathematical Sciences,"** SIAM. Highman's book.
4	Adrian Wallwork, **"English for Writing Research Papers,"** Springer New York Dorecht Heidelberg London, 2011

PO CO	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	*Understand and appreciate the process of*					1	1	1	1	1	1	1

	writing a good research paper											
CO2	*Apply their gained knowledge in writing a research paper*					1	1	1	1	1	1	1
CO3	*Analyse and assess the quality of their research paper*					1	1	1	1	1	1	1

18AC02	DISASTER MANAGEMENT	L	T	P	C
		2	0	0	0

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

INTRODUCTION

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

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

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

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

Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India.

Total (L+T)= 20 Periods

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*

Reference:

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.

PO / CO	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11

CO1	*Learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.*					1	1	1	1	1	1	1
CO2	*Critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives*					1	1	1	1	1	1	1
CO3	*Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations*					1	1	1	1	1	1	1
`CO4	*Critically understand the strengths and weaknesses of disaster management approaches*					1	1	1	1	1	1	1

18AC03	SANSKRIT FOR TECHNICAL KNOWLEDGE	L	T	P	C
		2	0	0	0

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

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

Unit II	8	+	0

Order-Introduction of roots-Technical information about Sanskrit Literature

Unit III	8	+	0

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

Total (L+T)= 24 Periods

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*

Suggested Reading:

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

PO / CO	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	*Understanding basic Sanskrit language*					1	1	1	1	1	1	1
CO2	*Ancient Sanskrit literature about science & technology can be understood*					1	1	1	1	1	1	1
CO3	*Being a logical language will help to develop logic in students*					1	1	1	1	1	1	1

18AC04	VALUE EDUCATION	L	T	P	C
		2	0	0	0

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

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

Unit II		6	+	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

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

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 (L+T)= 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.

PO / CO	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	*Knowledge of self-development*					1	1	1	1	1	1	1
CO2	*Critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple*					1	1	1	1	1	1	1

	perspectives											
CO3	*Learn the importance of Human values*					1	1	1	1	1	1	1
CO4	*Developing the overall personality*					1	1	1	1	1	1	1

18AC05	CONSTITUTION OF INDIA	L	T	P	C
		2	0	0	0

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 I	HISTORY OF MAKING OF THE INDIAN CONSTITUTION	4	**+**	**0**
History, Drafting Committee, (Composition & Working)				
Unit II	PHILOSOPHY OF THE INDIAN CONSTITUTION	4	**+**	**0**
Preamble, Salient Features				
Unit III	CONTOURS OF CONSTITUTIONAL RIGHTS & DUTIES	4	**+**	**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**
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**
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
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 (L+T)= 24 Periods

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.*

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.

PO / CO	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
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*					1	1	1	1	1	1	1
CO2	*Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India*					1	1	1	1	1	1	1
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*					1	1	1	1	1	1	1
CO4	*Discuss the passage of the Hindu Code Bill of 1956.*					1	1	1	1	1	1	1

18AC06	PEDAGOGY STUDIES	L	T	P	C
		2	0	0	0

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**

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**

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

Unit III — **4 + 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**

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**

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

Total (L+T)= 16 Periods

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?*

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.

PO / CO	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	*What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?*					1	1	1	1	1	1	1
CO2	*What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?*					1	1	1	1	1	1	1
CO3	*How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?*					1	1	1	1	1	1	1

18AC07	STRESS MANAGEMENT BY YOGA	**L**	**T**	**P**	**C**
		2	**0**	**0**	**0**

Course Objectives:

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

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

Definitions of Eight parts of yoga

Unit II	**8**	**+**	**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**

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 (L+T)= 24 Periods

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 also*
CO2	:	*Improve efficiency*

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

PO / CO	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	*Develop healthy mind in a healthy body thus improving social health also*					1	1	1	1	1	1	1
CO2	*Improve efficiency*					1	1	1	1	1	1	1

18AC08	PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS	L	T	P	C
		2	0	0	0

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.

Unit I	8	+	0

Neetisatakam-Holistic development of personality
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	8	+	0

Approach to day to day work and duties.
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	8	+	0

Statements of basic knowledge.
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 (L+T)= 24 Periods

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.*

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.

PO / CO	CO Statement	PO1	PO 2	PO 3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO1 1
CO1	*Study of Shrimad-Bhagwad-Geeta will help the student in*					1	1	1	1	1	1	1

	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*					1	1	1	1	1	1	1
CO3	*Study of Neetishatakam will help in developing versatile personality of students.*					1	1	1	1	1	1	1

18PESE1	PATTERN RECOGNITION	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To understand pattern and unsupervised classification.
2.	To perform feature extraction and selection.
3.	To understand structural pattern recognition.

Unit I	PATTERN CLASSIFIER	9	+	0

Overview of pattern recognition – Discriminant functions – Supervised learning – Parametric estimation – Maximum likelihood estimation – Bayesian parameter estimation – Perceptron algorithm – LMSE algorithm – Problems with Bayes approach – Pattern classification by distance functions – Minimum distance pattern classifier.

Unit II	UNSUPERVISED CLASSIFICATION	9	+	0

Clustering for unsupervised learning and classification – Clustering concept – C-means algorithm – Hierarchical clustering procedures – Graph theoretic approach to pattern clustering – Validity of clustering solutions.

Unit III	STRUCTURAL PATTERN RECOGNITION	9	+	0

Elements of formal grammars – String generation as pattern description – Recognition of syntactic description – Parsing – Stochastic grammars and applications – Graph based structural representation.

Unit IV	FEATURE EXTRACTION AND SELECTION	9	+	0

Entropy minimization – Karhunen – Loeve transformation – Feature selection through functions approximation – Binary feature selection.

Unit V	RECENT ADVANCES	9	+	0

Neural network structures for Pattern Recognition – Neural network based Pattern associators – Unsupervised learning in neural Pattern Recognition – Self-organizing networks – Fuzzy logic – Fuzzy pattern classifiers – Pattern classification using Genetic Algorithms

Total (L+T)= 45 Periods

Course Outcomes:

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

CO1	*:*	*To solve pattern and unsupervised classification problems.*
CO2	*:*	*To perform feature extraction and selection.*
CO3	*:*	*To execute structural pattern recognition.*

Text Books:

1.	Robert J.Schalkoff, Pattern Recognition Statistical, Structural and Neural Approaches, John Wiley & Sons Inc., New York, 1992.
2.	Tou and Gonzales, Pattern Recognition Principles, Wesley Publication Company, London, 1974

Reference Books:

1.	Duda R.O., and Har P.E., Pattern Classification and Scene Analysis, Wiley, New York, 1973.
2.	Morton Nadier and Eric Smith P., Pattern Recognition Engineering, John Wiley & Sons, New York, 1993

E References:

1.	https://www.geeksforgeeks.org/pattern-recognition-introduction/

PO / CO	CO Statement	PO1	PO 2	PO 3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO1 1
CO1	*To solve pattern and unsupervised classification problems.*					2	1	1	2	1	2	1

CO2	*To perform feature extraction and selection.*					1	1	2	1	1	2	1
CO3	*To execute structural pattern recognition.*					1	1	1	2	1	3	3