JERUSALEM COLLEGE OF ENGINEERING
(An Autonomous Institution Affiliated to Anna University, Chennai)

VISION OF THE INSTITUTION

Jerusalem College of Engineering is committed in emerging as an international institution of excellence in imparting finest quality engineering, technology and management education rooted in ethical and societal values through various academic programmes, multi-disciplinary research, consultancy and entrepreneurship activities and hence to contribute towards social transformation and nation building.

MISSION OF THE INSTITUTION

- Generating abundant resources and making conducive policies, the management led by the Chief Executive Officer strives towards promoting globally competitive academic programmes augmented with value added courses, in-plant training activities, co-curricular activities and ambience that support intellectual growth and skill acquisition

- Promoting collaborative trans-border research programmes continuing education in synergy with academia, industries and research organizations leading to real time solutions and life-long learning

- Transforming young men and women into competent professionals and entrepreneurs motivated by a passion for professional excellence, driven by human values and proactively engage in the betterment of the society through innovative practices and academic excellence

- Facilitating effective interaction among faculty members and students and fostering network of alumni, industries, institutions and other stake-holders for successful career gain and placement

JERUSALEM COLLEGE OF ENGINEERING
(AN AUTONOMOUS INSTITUTION TO ANNA UNIVERSITY, CHENNAI)

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

VISION OF THE DEPARTMENT

Department of Electrical and Electronics Engineering is committed to produce **high profile, competent** and **disciplined** Engineers with **technical knowledge**, **ethical leadership** and **entrepreneurship** quality to contribute towards social transformation and nation building.

MISSION OF THE DEPARTMENT

- To make our graduates **highly competent** and expert in practical problem solving with abstract thinking skills.
- To endow students with high quality **technical knowledge** of electrical sciences through innovative teaching and research practices.
- To empower students with leadership and **entrepreneurship** quality, capable of providing their professional mettle with excellent communication skills.
- To encourage **cross border research** with innovative ideas and to impart the quality of life-long learning based on ethical values.

JERUSALEM COLLEGE OF ENGINEERING

(An Autonomous Institution, Affiliated to Anna University)

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

M.E - POWER ELECTRONICS AND DRIVES

REGULATIONS 2021

CHOICE BASED CREDIT SYSTEM

PROGRAMME OUTCOMES (POs):

POs	PROGRAMME OUTCOMES
PO1:	An ability to independently carry out research/ investigation and development work to solve practical problems
PO2:	An ability to write and present a substantial technical report/ document
PO3:	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
PO 4:	Ability to comprehend the need for various power electronics converters and applying the fundamental principles for analyzing the different modes of their operation.
PO 5:	Ability to analyze, design, simulate and test the various range of drive schemes for E-Vehicle applications.
PO 6:	Ability to understand the power generation from various renewable sources, to analyze the schemes for extracting the maximum power and to know the importance of energy storage systems.

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

M.E - POWER ELECTRONICS AND DRIVES

REGULATIONS 2021

CHOICE BASED CREDIT SYSTEM

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

PEO1:	To prepare the students for successful career in electrical power industry, research and teaching institutions.
PEO2:	To analyze power electronic supply/ machine drive problems.
PEO3:	To design and develop the power electronic converter/drive systems.
PEO4:	To develop the ability to analyze the dynamics in power electronic converters/drives systems
PEO5:	To introduce them to the sustainable energy generation technologies.
PEO6:	To promote student awareness for the lifelong learning and introduce them to professional ethics.

PEO / PO Mapping:

Program Educational Objectives	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
PEO 1	✓	✓	✓	✓	✓	✓
PEO 2	✓	✓		✓	✓	
PEO 3	✓		✓	✓	✓	✓
PEO 4	✓		✓		✓	✓
PEO 5	✓				✓	
PEO 6		✓			✓	

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M.E - POWER ELECTRONICS AND DRIVES

REGULATIONS 2021

CHOICE BASED CREDIT SYSTEM

Summary

S.NO	CATEGORY	Credits as per Semester				Total Credits	Percentage (%)
		1	2	3	4		
1	FC	3	-	-	-	3	4.2
2	PC	13	16	-	-	29	41.2
3	PE	3	3	6	-	12	17.1
4	OE	-	-	3	-	3	4.2
5	EEC	1	2	8	12	23	33
TOTAL						70	100

CURRICULUM - I TO IV SEMESTERS

SEMESTER 1

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	JMA5102	Applied Mathematics	FC	3	2	2	0	3
2	JPX5101	Analysis of Electrical Machines	PC	3	3	2	0	4
3	JPX5102	Analysis and Design of Power Converters	PC	5	3	2	0	4
4	JPX5103	Electric and Hybrid Vehicles	PC	5	3	0	0	3
5		Professional Elective I	PE	3	3	0	0	3
6		Non Credit Mandatory Course	NCM	3	3	0	0	0
PRACTICALS								
7	JPX5111	Power Electronics Circuits Laboratory	PC	4	0	0	4	2
8	JPX5121	Technical Seminar	EEC	2	0	0	2	1
Total				28	17	6	6	20

SEMESTER 2

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	JPX5201	Analysis of Electrical Drives	PC	5	3	2	0	4
2	JPX5202	Vector Control of AC Machines	PC	5	3	2	0	4

3	JPX5203	Special Electrical Machines	PC	3	3	0	0	3
4	JPX5204	Microcontroller Based System Design	PC	3	3	0	0	3
5		Professional Elective II	PE	3	3	0	0	3
6		Non Credit Mandatory Course	NCM	3	3	0	0	0
PRACTICALS								
7	JPX5211	Electrical Drives Laboratory	PC	4	0	0	4	2
8	JPX5241	Mini Project	EEC	4	0	0	4	2
Total				30	18	4	8	21

SEMESTER 3

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1		Professional Elective III	PE	3	3	0	0	3
2		Professional Elective IV	PE	3	3	0	0	3
3		Open Elective I	OE	3	3	0	0	3
4	JRM5301	Research Methodology and IPR	EEC	2	2	0	0	2
PRACTICALS								
5	JPX5361	Project Phase I	EEC	12	0	0	12	6
Total				23	11	0	12	17

SEMESTER 4

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
PRACTICALS								
1	JPX5461	Project Phase II	EEC	24	0	0	24	12
Total				24			24	12

Total Number of Credits: 70

FOUNDATION COURSE (FC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	JMA5102	Applied Mathematics	FC	4	2	2	0	3

PROFESSIONAL CORE (PC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	JPX5101	Analysis of Electrical Machines	PC	3	3	2	0	4
2	JPX5102	Analysis and Design of Power Converters	PC	5	3	2	0	4
3	JPX5103	Electric and Hybrid Vehicles	PC	5	3	0	0	3
4	JPX5111	Power Electronics Circuits Laboratory	PC	4	0	0	4	2
5	JPX5201	Analysis of Electrical Drives	PC	5	3	2	0	4
6	JPX5202	Vector Control of AC Machines	PC	5	3	2	0	4
7	JPX5203	Special Electrical Machines	PC	3	3	0	0	3
8	JPX5204	Microcontroller Based System Design	PC	3	3	0	0	3
9	JPX5211	Electrical Drives Laboratory	PC	4	0	0	4	2

PROFESSIONAL ELECTIVE - I (PE)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	JPX5001	Power Semiconductor Devices	PE	3	3	0	0	3
2	JPX5002	Electromagnetic Field Computation and Modelling	PE	3	3	0	0	3
3	JPX5003	Control System Design for Power Electronics	PE	3	3	0	0	3
4	JPX5004	Analog and Digital Controller	PE	3	3	0	0	3

PROFESSIONAL ELECTIVE - II (PE)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	JPX5005	Applied Soft Computing	PE	3	3	0	0	3
2	JPX5006	High Voltage Direct Current Transmission	PE	3	3	0	0	3
3	JPX5007	Flexible AC Transmission Systems	PE	3	3	0	0	3
4	JPX5008	Electromagnetic interference and Compatibility	PE	3	3	0	0	3

PROFESSIONAL ELECTIVE - III (PE)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	JPX5009	Modern Rectifiers and Resonant Converters	PE	3	3	0	0	3
2	JPX5010	Electric Power Quality	PE	3	3	0	0	3
3	JPX5011	Solar and Energy Storage Systems	PE	3	3	0	0	3
4	JPX5012	Wind Energy Conversion Systems	PE	3	3	0	0	3

PROFESSIONAL ELECTIVE - IV (PE)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	JPX5013	SMPS and UPS	PE	3	3	0	0	3
2	JPX5014	Power Electronics for Renewable Energy Systems	PE	3	3	0	0	3
3	JPX5015	Non Linear Dynamic for Power Electronics Circuits	PE	3	3	0	0	3
4	JPX5016	Energy Management and Auditing	PE	3	3	0	0	3

OPEN ELECTIVE (OE)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	JPX9001	Intelligent Sensors for Engineering Applications	OE	3	3	0	0	3
2	JPX9002	Safety Engineering and Maintenance	OE	3	3	0	0	3
3	JPX9003	SMPS and UPS for Computer Applications	OE	3	3	0	0	3
4	JPX9004	Fundamentals of Nano science	OE	3	3	0	0	3
5	JPX9005	MEMS technology	OE	3	3	0	0	3
6	JPX9006	Power Plant Engineering	OE	3	3	0	0	3

EMPLOYMENT ENHANCEMENT COURSES (EEC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	JPX5121	Technical Seminar	EEC	2	0	0	2	1
2	JPX5241	Mini Project	EEC	4	0	0	4	2
3	JRM5301	Research Methodology and IPR	EEC	2	2	0	0	2
4	JPX5361	Project Phase I	EEC	12	0	0	12	6
5	JPX5461	Project Phase II	EEC	24	0	0	24	12

NON CREDIT MANDATORY COURSES (NCM)

S.No	Course Code	Course Title	Category	Contact Periods	L	T	P	C
1	JNC5001	English for Research Paper Writing	NCM	2	2	0	0	0
2	JNC5002	Disaster Management	NCM	2	2	0	0	0
3	JNC5003	Sanskrit for Technical Knowledge	NCM	2	2	0	0	0
4	JNC5004	Value Education	NCM	2	2	0	0	0
5	JNC5005	Constitution of India	NCM	2	2	0	0	0
6	JNC5006	Pedagogy Studies	NCM	2	2	0	0	0
7	JNC5007	Stress Management by Yoga	NCM	2	2	0	0	0
8	JNC5008	Personality Management through Life Enlightenment Skills	NCM	2	2	0	0	0

SEMESTER 1

JMA5102	APPLIED MATHEMATICS	L	T	P	C
		2	2	0	3

Course Objectives :

1.To develop the ability to apply the concepts of Fuzzy Algebra.

2.To explain the concepts of Matrix Theory in decomposition problems.

3.To elucidate problem solving through various methods in Linear Programming.

4.To familiarize the students in various concepts and methods in Calculus of Variations.

5.To enable students to understand Multivariate Analysis and its applications.

Unit 1 FUZZY SETS AND LOGIC **9**

Fuzzy sets – Properties and Operations – Fuzzy relations – Operations on Fuzzy relations - Classical logic – Multivalued logic – Fuzzy propositions – Fuzzy quantifiers.

Unit 2 MATRIX THEORY **9**

Elementary DC machine and analysis of steady state operation - Voltage and torque equations – Basic Types of DC machines-dynamic characteristics of permanent magnet and shunt DC motors – Time domain block diagrams - digital computer simulation of permanent magnet and shunt D.C. machines.

Unit 3 LINEAR PROGRAMMING REFERENCE FRAME THEORY **9**

Historical background –Equations of Transformation – transformation of variables from stationary to arbitrary reference frame –Commonly used reference frames – Transformation between reference frames- Transformation of a balanced set - variables observed from several frames of reference.

Unit 4 CALCULUS OF VARIATIONS INDUCTION MACHINES **9**

Three phase induction machine, equivalent circuit and analysis of steady state operation – free acceleration characteristics – voltage and torque equations in machine variables and arbitrary reference frame variables – analysis of dynamic performance for load torque variations – digital computer simulation.

Unit 5 MULTIVARIATE ANALYSIS SYNCHRONOUS MACHINES **9**

Three phase synchronous machine and analysis of steady state operation - voltage and torque equations in machine variables and rotor reference frame variables (Park's equations) – analysis of dynamic performance for load torque variations

Total : 45 Periods

Course Outcomes : At the end of the course, the student will be able

CO1 : To apply multivalued logic and fuzzy logic in problems.

CO2: To use matrix theory in practical applications and problem solving.

CO3: To solve linear programming problems through simplex and two phase methods and understand LP extensions: Transportation and Assignment Models.

CO4: To solve problems based on calculus of variations in engineering applications and get exposed to standard methods.

CO5: To understand multivariate analysis and use Principal Component Analysis in problems

REFERENCE :
1. George J. Klir and Yuan, B., Fuzzy sets and Fuzzy Logic, Theory and Applications, Prentice Hall of India Pvt. Ltd., 1997.
2. Richard Bronson, "Matrix Operations", Schaum's outline series, 2nd Edition, McGraw Hill, 2011
3. Taha, H.A., "Operations Research, An introduction", 10th edition, Pearson education, New Delhi, 2010
4. Gupta, A.S., Calculus of Variations with Applications, Prentice Hall of India Pvt. Ltd., New Delhi, 1997
5. Elsgolts, L., Differential Equations and the Calculus of Variations, MIR Publishers, Moscow, 1973
6. Richard A.Johnson and Dean W.Wichern, "Applied Multivariate Statistical Analysis", Pearson Education, Asia, 6th Edition, 2007.
WEB SITE REFERENCE:
1. https://nptel.ac.in/courses/108/104/108104157/
2. https://nptel.ac.in/courses/111/107/111107112/
3. https://nptel.ac.in/courses/111/102/111102012/
4. https://nptel.ac.in/courses/111/104/111104025/
5. https://nptel.ac.in/courses/111/104/111104024/

CO-PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	3	2	2	-	-
CO 2	3	3	2	2	-	-
CO 3	3	3	2	2	-	-
CO4	3	3	2	2	-	-
CO5	3	3	2	2	-	-

JPX5101	**ANALYSIS OF ELECTRICAL MACHINES**	**L T P C**
		3 2 0 4
Course Objectives :		
1.To provide knowledge about the fundamentals of magnetic circuits, energy, force and torque of multi-excited systems.		
2.To study the steady state and dynamic state operation of DC machine through mathematical modelling and simulation in digital computer.		
3.To provide the knowledge of reference frame theory transformations.		

4.To learn the steady state and dynamic state operation of three-phase induction machines using transformation theory based mathematical modeling and digital computer simulation.
5.To analyze the steady state and dynamic state operation of three-phase synchronous machines using transformation theory based mathematical modeling and digital computer simulation.
Unit 1 PRINCIPLES OF ELECTROMAGNETIC ENERGY CONVERSION 9+6
Magnetic circuits, permanent magnet, stored magnetic energy, co-energy - force and torque in singly and doubly excited systems – machine windings and air gap mmf –Winding Inductances and voltage equations.
Unit 2 DC MACHINES 9+6
Elementary DC machine and analysis of steady state operation - Voltage and torque equations – Basic Types of DC machines-dynamic characteristics of permanent magnet and shunt DC motors – Time domain block diagrams - digital computer simulation of permanent magnet and shunt D.C. machines.
Unit 3 REFERENCE FRAME THEORY 9+6
Historical background –Equations of Transformation – transformation of variables from stationary to arbitrary reference frame –Commonly used reference frames – Transformation between reference frames- Transformation of a balanced set - variables observed from several frames of reference.
Unit 4 INDUCTION MACHINES 9+6
Three phase induction machine, equivalent circuit and analysis of steady state operation – free acceleration characteristics – voltage and torque equations in machine variables and arbitrary reference frame variables – analysis of dynamic performance for load torque variations – digital computer simulation.
Unit 5 SYNCHRONOUS MACHINES 9+6
Three phase synchronous machine and analysis of steady state operation - voltage and torque equations in machine variables and rotor reference frame variables (Park's equations) – analysis of dynamic performance for load torque variations
Total : 75 Periods
Course Outcomes : At the end of the course, the student will be able
CO1 : To understand the principle of electromagnetic energy conversion.
CO2: To acquire knowledge about modelling of machine dynamics in Electrical engineering.
CO3: To understand about reference frame theories and transformation relationships.
CO4: To understand the steady state and dynamic state operation of three-phase induction machines
CO5: To understand the steady state and dynamic state operation of three-phase synchronous machines
REFERENCE :
1.Paul C.Krause, Oleg Wasyzczuk, Scott S, Sudhoff, "Analysis of Electric Machinery and Drive Systems", John Wiley, Second Edition, 2010..
2.P S Bimbhra, "Generalized Theory of Electrical Machines", Khanna Publishers, 2008

3.A.E, Fitzgerald, Charles Kingsley, Jr, and Stephan D, Umanx, " Electric Machinery", Tata McGraw Hill, 5th Edition, 1992
4.R. Krishnan, Electric Motor & Drives: Modeling, Analysis and Control, New Delhi, Prentice Hall of India, 2001
5.Ahmed Masmoudi, "Design and Electromagnetic Feature Analysis of AC Rotating Machines",Springer,2019.
6. Jimmie J. Cathey, " Electrical Machines ANALYSIS AND DESIGN APPLYING MATLAB",McGraw Hill,2001.
7. Juha Pyrhonen, Tapani Jokinen and Valeria Hrabovcov, "DESIGN OF ROTATING ELECTRICAL MACHINES", John Wiley & Sons, Ltd, 2008
8. K.M. Vishnu Murthy, "Computer-Aided Design of Electrical Machines", BS Publications, 2008.
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8. http://mooc.org
9. https://www.coursera.org
10. https://in.udacity.com

CO-PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	1	2	2	2	
CO 2	2	2	2	2	2	1
CO 3	1	1	1	1	2	
CO4	1	2	1	1	1	1
CO5	2	2	1	2	1	

JPX5102	**Analysis and Design of Power Converters**	**L T P C**
		3 2 0 4
Course Objectives :		
1.To study the operation and characteristics of single phase and three phase controlled rectifiers		
2.To apply switching techniques and basic topologies of DC-DC switching regulators		
3.To impart knowledge on the operation and characteristics of inverters		
4.To study various types of multi-level inverts.		

5.To comprehend the concepts of AC-AC power converters and their applications.
Unit 1 SINGLE PHASE AND THREE PHASE AC-DC CONVERTERS 9+6
Operation of single-phase and three phase half controlled and fully controlled converters with R-L, R-L-E loads and freewheeling diodes – continuous and discontinuous modes of operation - inverter operation and its limit - performance parameters – effect of source impedance and overlap – reactive - power and power balance in converter circuits
Unit 2 DC-DC CONVERTERS 9+6
Limitations of linear power supplies - switched mode power conversion - Non-isolated DC- DC converters: operation and analysis of Buck, Boost, Buck-Boost, Cuk & SEPIC – continuous and discontinuous operation – Isolated converters: basic operation of Flyback, Forward and Push-pull topologies - Switching loss - hard switching, and basic principles of soft switching – Introduction to resonant switch converters.
Unit 3 INVERTERS 9+6
Principle of operation of half and full bridge inverters – Performance parameters – 180 degree and 120 degree conduction mode inverters with star and delta connected loads– Voltage control of inverters using various PWM techniques; various harmonic elimination techniques – Current source inverters – Multi level Inverters
Unit 4 MULTI LEVEL INVERTERS 9+6
Multilevel concept – generalized multilevel inverter topological advances - diode clamped – flying capacitor – cascaded type multilevel inverters - Comparison of multilevel inverters - application of multilevel inverters – PWM techniques for MLI – Single phase &Three phase Impedance source inverters - Filters.
Unit 5 AC-AC CONVERTERS 9+6
Principle of on-off and phase angle control – single phase AC voltage controller – analysis with R & RL load – Three phase AC voltage controller – principle of operation of cyclo converter – single phase and three phase cyclo converters – Introduction to matrix converters.
Total : 75 Periods
Course Outcomes : At the end of the course, the student will be able
CO1 : To understand the operating modes and characteristics of single phase and three phase converters.
CO2: To select and design dc-dc converter topologies for a broad range of power conversion applications.
Co3 : To acquire knowledge on single and three phase inverters.
Co4 : To understand the working of various multi-level invert types.
Co5 : To design the concepts of AC-AC power converters and their applications.
REFERENCE :
1 Ned Mohan,T.MUndeland and W.P Robbin, "Power Electronics: converters, Application and design" John Wiley and sons. Wiley India edition, 2006.

2 Rashid M.H., “Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Third Edition, New Delhi, 2004.
3 P.C. Sen, “Modern Power Electronics”, Wheeler Publishing Co, First Edition, New Delhi, 1998.
4 P.S.Bimbra, “Power Electronics”, Khanna Publishers, Eleventh Edition, 2003
5 Simon Ang, Alejandro Oliva, “Power-Switching Converters, Second Edition, CRC Press, Taylor & Francis Group, 2010
6 V.Ramanarayanan, “Course material on Switched mode power conversion”, 2007
3Alex Van den Bossche and VencislavCekovValchev, “Inductors and Transformers for Power Electronics”, CRC Press, Taylor & Francis Group, 2005
7 W. G. Hurley and W. H.Wolfle, “Transformers and Inductors for Power Electronics Theory, Design and Applications”, 2013 John Wiley & Sons Ltd.
8 Marian.K.Kazimierczuk and DariuszCzarkowski, “Resonant Power Converters”, John Wiley & Sons limited, 2011
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3. **https://www.coursera.org/**
4. **http://www.open.edu/openlearn/**
5. **http://www.open.edu/openlearn/**

CO-PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	2	2			
CO 2	2	2	2		1	
CO 3	2	2	2		1	1
CO4	2	2	2		1	1
CO5	2	2	2		1	1

JPX5103	**Electric and Hybrid Vehicles**	**L T P C**
		3 0 0 3
Course Objectives:		
1. To present a comprehensive overview of Electric and Hybrid Electric Vehicles		
2.To study the drive scheme for developing an electric hybrid vehicle depending on resources		
3.To impart knowledge on electric propulsion unit		
4. To learn about energy storage methods		
5.To impart knowledge about sizing the drive system and communication protocols.		

Unit 1	**Introduction to Hybrid Electric Vehicles** and **Conventional Vehicles** **9**
History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Basics of vehicle performance, vehicle power source characterization, transmission characteristics, and mathematical models to describe vehicle performance.	
Unit 2	**Hybrid Electric Drive-trains** **9**
Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis. Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.	
Unit 3	**Electric Propulsion unit** **9**
introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives	
Unit 4	**Energy Storage** **9**
Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Hybridization of different energy storage devices.	
Unit 5	**Sizing the drive system and Communication protocol** **9**
Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology- In vehicle networks-CAN protocol .	
Total : 45 Periods	
Course Outcomes : At the end of the course, the student will be able	
CO1 : To understand the comprehensive overview of Electric and Hybrid Electric Vehicles	
CO2 : To choose a suitable drive scheme for developing an electric hybrid vehicle depending on resources.	
CO3 : To gain knowledge on electric propulsion unit	
CO4 : To acquire knowledge about proper energy storage systems for vehicle applications.	
CO5 : To understand about sizing the drive system and communication protocols.	
REFERENCE :	
1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003	
2. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.	
3. Mehrdad Ehsani, YimiGao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.	
4. Ehsani, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles", CRC Press, 2019.	
5. A K Babu, "Electric and hybrid Vehicles", Khanna publication, 2019.	
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CO-PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	2	1	1	2	
CO 2	2	1	1	2	2	1
CO 3	2	1	1	2	2	
CO4	1	2	1	2	1	2
CO5	1	2	1	2	1	

JPX5111	**POWER ELECTRONICS CIRCUITS LABORATORY**	**L T P C**
		0 0 4 2

Course Objectives :

1.To familiarise with the digital tools used in generation of gate pulses for the power electronic switches

2.To be capable of implementing analog interfacing as well as control circuits used in a closed-loop control for power electronic system

3. To impart knowledge on mathematical modelling of power electronic circuits and implementing the same using simulation tools

4. To facilitate the students to design and fabricate a power converter circuits at appreciable voltage/power levels

5.To learn PCB design and fabrication to derive the criteria for the design of inverters for UPS, drives etc.,

LIST OF EXPERIMENTS

1.	Study of switching characteristics of IGBT and MOSFET with and without Snubber.
2.	Simulation and experimental verification of single-phase half wave-controlled converter with different loads.
3.	Simulation and experimental verification of single-phase fully-controlled converter with different loads.
4.	Study of Three phase Fully Controlled Rectifier, Half Controlled Rectifier with different Loads.
5.	Simulation and experimental verification of single phase VSI fed RL/RC load.
6.	Circuit Simulation of Voltage Source Inverter and study of spectrum analysis with and without filter using MATLAB/SCILAB
7.	Circuit Simulation of Three phase sine PWM inverter

8.	Design of Driver Circuit using IR2110
9.	Simulation and experimental verification of IGBT based Buck converter
10.	PCB design and fabrication of DC power supply using any PCB design software (open source-KiCAD/students version)
11.	Simulation of multilevel inverter topologies.
12.	Simulation and experimental verification of AC choppers
	Total : 60 Periods
Course Outcomes : At the end of the course, the student will be able	
CO1 : To understand the switching behavior of Power Electronic Switches and mathematical modeling of power electronic system and able to implement the same using simulation tools	
CO2 : To use microcontroller for power electronic control applications	
CO3: To acquire knowledge on mathematical modeling of power electronic circuits and implementing the same using simulation tools	
CO4: To design and implement analog circuits for Power electronic control applications	
CO5: To design and fabricate a power converter circuit at an reasonable power level and exposure to PCB designing and fabrication	
REFERENCE :	
1 Simon Ang, Alejandro Oliva, "Power-Switching Converters, Second Edition, CRC Press, Taylor & Francis Group, 2010	
2 V.Ramanarayanan, "Course material on Switched mode power conversion", 2007	
3Alex Van den Bossche and VencislavCekovValchev, "Inductors and Transformers for Power Electronics", CRC Press, Taylor & Francis Group, 2005	
4 W. G. Hurley and W. H.Wolfle, "Transformers and Inductors for Power Electronics Theory, Design and Applications", 2013 John Wiley & Sons Ltd.	
5. Lab Manual	
WEB SITE REFERENCE:	
1.	www.nptel.com
2.	**https://www.iare.ac.in/sites/default/files/lab1/ELECTRICAL%20DRIVES%20AND%20SIMULATION%20BPE102.pdf**

CO-PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	1			1	
CO 2	2	2		2	1	
CO 3	2	1	1		1	2

CO4	2	1			1	
CO5	2	2		2	1	

JPX5121	**TECHNICAL SEMINAR**	**L T P C**
		0 0 2 1
Course Objectives :		
1. To encourage the students to study advanced engineering developments.		
2. To prepare and present technical reports.		
3. To encourage the students to use various teaching aids such as overhead projectors, power point presentation and demonstrative models.		
METHOD OF EVALUATION		
During the seminar session each student is expected to prepare and present a topic on engineering/ technology, for a duration of about 8 to 10 minutes. In a session of three periods per week, 15 students are expected to present the seminar. Each student is expected to present atleast twice during the semester and the student is evaluated based on that. At the end of the semester, he / she can submit a report on his / her topic of seminar and marks are given based on the report. A Faculty guide is to be allotted and he / she will guide and monitor the progress of the student and maintain attendance also. Evaluation is 100% internal.		
		Total : 30 Periods
Course Outcomes : At the end of the course, the student will be able		
CO1 : To review, prepare and present technological developments.		
CO2 : To face the placement interviews		

CO-PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	2	2		1	
CO 2	1	2	1		2	
CO 3			1		1	2
CO 4		2	1		1	
CO 5	1		1			2

SEMESTER 2

JPX5201	ANALYSIS OF ELECTRICAL DRIVES	L	T	P	C
		3	2	0	4

Course Objectives :

1. To provide overview about fundamentals and mechanical systems of DC motors
2. To study the operation of the converter / chopper fed DC drive, both qualitatively and quantitatively
3. To learn the current and speed controllers for a closed loop solid state DC motor drive.
4. To study the operation of VSI &CSI fed stator controlled induction motor drives
5. To learn the speed control of induction motor drive from rotor sides.

Unit 1 DC MOTORS FUNDAMENTALS AND MECHANICAL SYSTEMS 9+6

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

Unit 2 CONVERTER AND CHOPPER CONTROL 9+6

Principle of phase control – Fundamental relations; Analysis of series and separately excited DC motor with single-phase and three-phase converters –performance parameters, performance characteristics. Introduction to time ratio control and frequency modulation; chopper-controlled DC motor – performance analysis, multi-quadrant control - Chopper based implementation of braking schemes; Related problems.

Unit 3 CLOSED LOOP CONTROL 9+6

Modeling of drive elements – Equivalent circuit, transfer function of self, separately excited DC motors; Linear Transfer function model of power converters; Sensing and feeds back elements - Closed loop speed control – current and speed loops, P, PI and PID controllers – response comparison. Simulation of converter and chopper fed DC drive.

Unit 4 VSI AND CSI FED STATOR CONTROLLED INDUCTION MOTOR CONTROL 9+6

AC voltage controller – six step inverter voltage control-closed loop variable frequency PWM inverter fed induction motor (IM) with braking-CSI fed IM variable frequency motor drives – pulse width modulation techniques – simulation of closed loop operation of stator-controlled induction motor drives.

Unit 5 ROTOR CONTROLLED INDUCTION MOTOR DRIVES 9+6

Static rotor resistance control - injection of voltage in the rotor circuit – static scherbius drives – static and modified Kramer drives – sub-synchronous and super-synchronous speed operation of induction machines – simulation of closed loop operation of rotor-controlled induction motor drives.

Total : 75 Periods

Course Outcomes : At the end of the course, the student will be able

CO1 : To understand about fundamentals and mechanical systems of DC motors

CO2. To comprehend, design and develop the converter / chopper fed DC drive.
CO3: To understand about the current and speed controllers for a closed loop solid state DC motor drive.
CO4: To gain knowledge on the operation of VSI &CSI fed stator controlled induction motor drives
CO5: To design and develop the speed control of induction motor drive using rotor control methods.
REFERENCE :
1 Gopal K Dubey, "Power Semiconductor controlled Drives", Prentice Hall Inc., NewYersy, 1989.
2. R.Krishnan, "Electric Motor Drives – Modeling, Analysis and Control",Prentice-Hall of India Pvt. Ltd., New Delhi,2010.3 P.C. Sen, "Modern Power Electronics", Wheeler Publishing Co, First Edition, New Delhi, 1998.
3. Bimal K Bose, "Modern Power Electronics and AC Drives", Pearson Education Asia2002.
4. Gopal K.Dubey, "Fundamentals of Electrical Drives", Narosal Publishing House, New Delhi, Second Edition, 2009
5. Vedam Subramanyam, "Electric Drives – Concepts and Applications", Tata McGrawHill publishing company Ltd., New Delhi, 2002.
6.P.C Sen "Thyristor DC Drives", John wiely and sons, New York, 1981.
7. W.Leonhard, "Control of Electrical Drives", Narosa Publishing House, 1992
8. Murphy J.M.D and Turnbull, "Thyristor Control of AC Motors", Pergamon Press, Oxford, 1988
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1. www.nptel.com
2. **https://swayam.gov.in**
3. **https://www.coursera.org**
4. **http://www.open.edu/openlearn**
5. **http://www.open.edu/openlearn**

CO-PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	2	2	2	2	2
CO 2	2	2	2	2	2	1
CO 3	2	1	2	2	2	1
CO4	2	2	2	1	2	1
CO5	2	2	1	2	2	2

JPX5202	VECTOR CONTROL OF AC MACHINES	L	T	P	C
		3	2	0	4

Course Objectives :

1.To study the space phasor model of alternating current machines.

2. To learn the field oriented control for permanent magnet synchronous machines.

3. To impart knowledge on the concept of vector control based salient pole machines.

4. To study the stator flux oriented control techniques of induction machines.

5. To learn the rotor flux oriented control of induction machines.

Unit 1 SPACE PHASOR MODEL OF AC MACHINES 9+6

Introduction-Smooth Air gap machine and salient pole machines- flux linkage space phasors - voltage equation- expression for electromagnetic torque.

Unit 2 VECTOR CONTROL OF PM SYNCHRONOUS MACHINE 9+6

PMSM with surface mounted magnets- control scheme for of rotor oriented controlled PMSM with interior magnets-stator flux oriented control- rotor oriented control

Unit 3 VECTOR CONTROL OF SALIENT POLE MACHINE WITH ELECTRICALLY EXCITED ROTOR 9+6

Magnetizing flux oriented control –variable frequency operation of salient pole synchronous machine-rotor oriented control of reluctance machines-considerations of the effects of main flux saturation

Unit 4 STATOR FLUX ORIENTED CONTROL OF INDUCTION MACHINE 9+6

Squirrel cage machine -Electromagnetic torque-voltage equations, doubly fed induction machines-control-static converter cascade, magnetizing flux oriented control of induction machine.

Unit 5 ROTOR FLUX ORIENTED CONTROL OF INDUCTION MACHINE 9+6

Control by a VSI – voltage equation-decoupling circuits- electromagnetic torque-voltage equations-current controlled PWM inverter- control by CSI – current controlled operation control of slip ring induction machines

Total : 75 Periods

Course Outcomes : At the end of the course, the student will be able

CO1: To carry out space phasor model for electrical machines.

CO2: To synthesis the vector controller for permanent magnet synchronous machines.

CO3: To compute and analyze the controllers of salient pole machines.

CO4: To understand the concept of stator flux oriented control of induction machine.

CO5: To acquire knowledge on rotor flux-oriented control of induction machine.

REFERENCE :

1. Peter Vas, “Vector control of AC machines/Peter Vas”, Oxford [England]: Clarendon Press; New York: Oxford University Press, 1990.

2. BimalK.Bose, “Modern Power Electronics and AC Drives”, Prentice Hall PTR, 2002.

3. Peter Vas, “Sensorless Vector and Torque Control”, Oxford University press, 1998.

4. PaulC.Krause, Oleg Wasyzczuk, Scott S, Sudhoff, “Analysis of Electric Machinery and Drive Systems”, John Wiley, Second Edition, 2010.

5.R.Krishnan, “Permanent Magnet Synchronous and Brushless DC Motor Drives”,CRC Press,2010.

WEB SITE REFERENCE:
1. www.nptel.com
2. https://alison.com/
3. https://swayam.gov.in/
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CO-PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2		2		1	
CO 2	2	1	2	1		2
CO 3	2		2		2	2
CO4	2	1		1	2	
CO5	2		2			1

JPX5203	SPECIAL ELECTRICAL MACHINES	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 synchronous motors

3.To study the working and characteristics 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 1 PERMANENT MAGNET BRUSHLESS DC MOTORS **9**

Fundamentals of Permanent Magnets- Types- Principle of operation- Magnetic circuit analysis EMF and Torque equations- Characteristics and control

Unit 2 PERMANENT MAGNET SYNCHROUNOUS MOTORS **9**

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 3 SWITCHED RELUCTANCE MOTORS **9**

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

Unit 4 STEPPER MOTORS **9**

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

Unit 5	**OTHER SPECIAL MACHINES** **9**
Principle of operation and characteristics of Hysteresis motor – AC series motors – Linear motor – Applications.	
Total : 45 Periods	
Course Outcomes : At the end of the course, the student will be able	
CO1 : To understand the fundamental concepts of permanent magnets and the operation of permanent magnet brushless DC motors.	
CO2 : To gain knowledge on the characteristics and control of permanent magnet synchronous motors	
CO3: To understand the working, characteristics and control of Switched reluctance motors.	
CO4: To acquire knowledge on stepper motors and its applications.	
CO5: To understand the operation and applications of Hysteresis motor, AC series motor and Linear motor.	
REFERENCE :	
1.T.J.E. Miller, 'Brushless magnet and Reluctance motor drives', Claredon press, London, 1989.	
2. R.Krishnan, ' Switched Reluctance motor drives' , CRC press, 2001.	
3. T.Kenjo, ' Stepping motors and their microprocessor controls', Oxford University press, New Delhi, 2000	
4. T.Kenjo and S.Nagamori, 'Permanent magnet and Brushless DC motors', Clarendon press, London, 1988	
5.R.Krishnan, ' Electric motor drives' , Prentice hall of India,2002.	
6.D.P.Kothari and I.J.Nagrath, ' Electric machines', Tata Mc Graw hill publishing company, New Delhi, Third Edition, 2004..	
7.R.Krishnan, "Permanent Magnet Synchronous and Brushless DC Motor Drives",CRC Press,2010.	
8.Berker Bilgin,,James Weisheng Jiang and Ali Emadi "Switched Reluctance Motor Drives", CRC Press, 2019.	
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2.	**https://swayam.gov.in**
3.	**https://www.coursera.org**
4.	**http://www.open.edu/openlearn**
5.	**http://www.open.edu/openlearn**

CO-PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	2	2	1	1	1
CO 2	2	2	2	1		2
CO 3	2	2	2	1	2	1
CO4	2	2	2	1		
CO5	2	2		2		1

JPX5204	**MICROCONTROLLER BASED SYSTEM DESIGN**	**L T P C**
		3 0 0 3
Course Objectives :		
1.To study the architecture and programming of 8051.		
2. To impart knowledge on internal peripheral units of 8051 and using them for interfacing applications.		
3. To study the architecture and instruction set of PIC 18 series microcontrollers		
4. To impart knowledge on internal peripheral units of PIC 18 microcontrollers.		
5. To learn the system design applications		
Unit 1	**8051 ARCHITECTURE AND PROGRAMMING**	**9**
Architecture –memory organization –addressing modes –instruction set–Arithmetic Instructions – Logical Instructions –Single bit Instructions–Assembly language programming		
Unit 2	**8051 PERIPHERALS**	**9**
Timers -Interrupts -I/O ports, Interfacing I/O Devices-LCD display–Serial Communication –Timer /Counter Programming –Interrupt Programming		
Unit 3	**PIC18 MICROCONTROLLER**	**9**
Architecture –memory organization –RAM & ROM Allocation -addressing modes –instruction set – PIC programming in Assembly & C –I/O port, Data Conversion -MPLAB IDE.		
Unit 4	**PERIPHERAL OF PIC MICROCONTROLLER**	**9**
Timer programming –Serial Port programming –Interrupt Programming –CCP Programming -A/D converter -DAC and Sensor Interfacing –SPI and I2C interfacing.		
Unit 5	**SYSTEM DESIGN APPLICATIONS**	**9**
Interfacing LCD Display –Keypad Interfacing -Generation of Gate signals for converters and Inverters -Motor Control: Relay, PWM -DC and stepper motors –Measurement of frequency -Stand alone Data Acquisition System.		
		Total : 45 Periods
Course Outcomes : At the end of the course, the student will be able		
CO1 : To develop programming of 8051 microcontroller based on its architecture.		
CO2 : To design and Implement the Memory & Peripheral Devices interface with 8051 controller		
CO3: To develop programs based on the architecture and instruction set of PIC 18 series microcontroller		

CO4:To design and implement the peripheral devices interface with PIC 18 controller
CO5: To design interfacing applications based on internal peripheral units of PIC 18 microcontrollers and programming
REFERENCE :
1. Muhammad Ali Mazidi, Janice G. Mazidi and Rolin D. McKinlay, "The 8051 Microcontroller and Embedded Systems" Prentice Hall, 2005.
2. Kenneth J Ayala "The 8051 Microcontroller, Architecture, Programming and Applications" 2nd edition Penram International Publishing, 1996.
3. Muhammad H. Rashid, "The 8051 Microcontroller and Embedded Systems, Volume 1" Prentice Hall, 2000.
4. Muhammad Ali Mazidi, Rolin D.Mckinlay , danny Causey, 'PIC Microcontroller and Embedded Systems using Assembly and C for PIC 18', Pearson Education , 2008.
5. Jhon B. Peatmam, "Design with PIC microcontrollers"Pearson Education, 2002
6. Martin Bates "PIC Microcontroller: An Embedded Systems Approach to Microcontrollers", Newnes press, jan 2012.
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1. www.nptel.com
2. https://alison.com/
3. https://swayam.gov.in/
4. http://mooc.org/
5. https://www.edx.org/

CO-PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	1		1	2	2
CO 2	2		1	2	2	2
CO 3	2	1			2	2
CO4	2		2	1	2	2
CO5	1	1	1	1	1	1

JPX5211	**ELECTRICAL DRIVES LABORATORY**	**L T P C**
		0 0 4 2
Course Objectives :		
1.To impart knowledge on developing the Simulink models for DC and AC drives.		
2.To get exposed in generating the firing pulses for converters and inverters using digital processors		
3.To get an overview about the design of controllers for linear and nonlinear systems		
4.To get an overview about the closed loop system design using hardware simulation		

LIST OF EXPERIMENTS
1. Speed control of Converter fed DC motor.
2. Design and simulation of DC motor
3. Speed control of Chopper fed DC motor.
4. V/f control of three-phase induction motor.
5. Micro controller-based speed control of Stepper motor.
6. Speed control of BLDC motor.
7. Design and Simulation of BLDC motor
8. DSP based speed control of SRM motor.
9. Voltage Regulation of three-phase Synchronous Generator.
10. Cycloconverter fed Induction motor drives
11. Single phase Multi Level Inverter based induction motor drive
12. Study of power quality analyser
Total : 60 Periods
Course Outcomes : At the end of the course, the student will be able
CO1:To simulate and perform experiment on DC and AC drives
CO2:To generate the firing pulse for the power electronic converters
CO3:To demonstrate and design the controllers for linear and nonlinear systems
CO4:To design and develop the Simulink model for closed loop control of Drives.
REFERENCE :
1.Gopal K Dubey, “Power Semiconductor controlled Drives”, Prentice Hall Inc., NewYersy, 1989.
2. R.Krishnan, “Electric Motor Drives – Modeling, Analysis and Control”,Prentice-Hall of India Pvt. Ltd., New Delhi,2010.3 P.C. Sen, “Modern Power Electronics”, Wheeler Publishing Co, First Edition, New Delhi, 1998.
3. Bimal K Bose, “Modern Power Electronics and AC Drives”, Pearson Education Asia2002.
4. W.Leonhard, “Control of Electrical Drives”, Narosa Publishing House, 1992
5.Lab Manual
WEB SITE REFERENCE:
1. www.nptel.com
2. https://www.iare.ac.in/sites/default/files/lab1/ELECTRICAL%20DRIVES%20AND%20SIMULATION%20BPE102.pdf
3. https://www.vlab.co.in/broad-area-electrical-engineering
4. https://www.mathworks.com/academia/books/analysis-and-control-of-electric-drives-mohan.html
5. https://www.nit.ac.in/pdf/labs/electrical/drives.pdf

CO-PO MAPPING :

	PO1	PO2	PO3		PO4	PO5	PO6
CO 1	2	1	1		2	2	1
CO 2	2	2	2	2	1	2	1
CO 3	2	1	2	2	2	2	1
CO4	2	2	1	1	1	2	1

JPX5241	**MINI PROJECT**	**L T P C**
		0 0 4 2

Course Objectives :

1. To develop the ability to solve a specific problem right from its identification and literature review till the successful solution of the same

2.To train the students in preparing project reports and to face reviews and viva voce examination.

3.Each student works on a topic approved by the head of the department and prepares a comprehensive mini project report after completing the work to the satisfaction. The progress of the project is evaluated based on a minimum of two reviews. The review committee may be constituted by the Head of the Department. A mini project report is required at the end of the semester. The mini project work is evaluated based on oral presentation and the mini project report jointly by external and internal examiners constituted by the Head of the Department.

Method of Evaluation: The assessment of Mini Project consists of assessment by Guide and assessment by moderator in the following areas:

- Technical Knowledge and skills
- Project Report
- Oral Presentation
- Attendance and Participation
- Logbook / Interview
- Demonstration

A project to be developed based on one or more of the following concepts :

Rectifiers, DC-DC Converters, Inverters, cycloconverters, DC drives, AC drives, Special Electrical Machines, Renewable Energy Systems, Linear and non-linear control systems, Power supply design for industrial and other applications, AC-DC power factor circuits, micro grid, smart grid and robotics.

Total : 60 Periods

Course Outcomes : At the end of the course, the student will be able

CO1: To acquire practical knowledge within the chosen area of technology for project development

CO2:To identify, analyze, formulate and handle programming projects with a comprehensive and systematic approach
CO3:To contribute as an individual or in a team in development of technical projects
CO4: To develop effective communication skills for presentation of project related activities

CO-PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	2	2	2	1	2
CO 2	2	2	2	2	1	2
CO 3	1	1	2	1	1	2
CO4	1	1	1	1	1	1

SEMESTER 3

JRM5301	RESEARCH METHODOLOGY AND IPR	L	T	P	C
		2	0	0	2

Course Objectives :

1. To identify and prepare the research problem.
2. To reexamine the literature and research ethics.
3. To associate the research design in the report.
4. To explore and integrate the Intellectual Property Rights in research.
5. To be aware of patent procedure and penalties.

Unit 1 RESEARCH PROBLEM FORMULATION **6**

Meaning of research problem- Sources of research problem, characteristics of a good research problem, errors in selecting a research problem, scope and objectives of research problem- Types of research- Research Approaches-Research Process-Approaches of investigation of solutions for research problem.

Unit 2 LITERATURE REVIEW **6**

Reviewing the literature- Procedure for reviewing the literature-Effective literature studies approaches, analysis, plagiarism, and research ethics.

Unit 3 TECHNICALWRITING /PRESENTATION **6**

Important Concepts Relating to Research Design-Effective technical writing, how to write report, paper, developing a research proposal, format of research proposal.

Unit 4 INTELLECTUAL PROPERTY RIGHTS (IPR) **6**

Need for Intellectual Property right – Nature, scope and importance of IPR- Types of Intellectual property – IPR in Technological research and innovation – National IPR Policy- objectives and achievements – Issues in India's IPR Regime.

Unit 5 PATENTS **6**

Core objectives – elements of patentability – Patent search – Registration procedure, specification – rights and duties of patentee, assignment and license, restoration of lapsed patents, infringement, remedies & penalties – procedure for grants of patents.

Total : 30 Periods

Course Outcomes : At the end of the course, the student will be able

CO1 : To investigate and formulate the research problem.

CO2 : To correlate the research analysis through review of literature.

CO3 : To prepare research report effectively.

CO4 : To apply IPR in Technological research and innovation.

CO5 : To be aware with the adequate knowledge on patent and rights.

TEXT BOOKS

1.Kothari, C.R., 2004, Research Methodology: Methods and Techniques. New Age International.

2.Catherine J. Holland, "Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets", Entrepreneur Press, 2007.

3. David Hunt, Long Nguyen, Matthew Rodgers, "Patent searching: tools & techniques", Wiley, 2007.

4. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, "Professional Programme Intellectual Property Rights, Law and practice", September 2013. 4.

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1.Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners" 2010

2. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers

3.Robert P. Merges, Peter S. Menell and Mark A. Lemley, "Intellectual Property in New Technological Age", Aspen Publishers, 2016.

4.Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.

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2. https://gradcoach.com/what-is-research-methodology/

3. https://www.scribbr.com/category/methodology/

4. Cell for IPR Promotion and Management (http://cipam.gov.in/)

5. World Intellectual Property Organisation (https://www.wipo.int/about-ip/en/)

6. Office of the Controller General of Patents, Designs & Trademarks (http://www.ipindia.nic.in/)

CO-PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	1	3	3	3	2
CO 2	1	3	3	3	2	2
CO 3	1	1	1	2	2	2
CO4	3	2	3	2	1	1
CO5	3	2	3	2	1	1

JPX5361 PROJECT WORK - PHASE - 1 **L T P C**

0 0 12 6

Course Objectives :

1. To identify a specific problem for the present need of the society and collecting information related to the same through detailed literature survey.

2.To develop the methodology to solve the identified problem.

3. To design, analyze and simulate the chosen problem using the software package.

4. To train the students in preparing project reports and to face reviews and viva-voce examination.

Method of Evaluation:

The students in a group of 3 to 4 work on a topic approved by the Head of the Department under the guidance of a faculty member, prepare a comprehensive project report after completing the work to the satisfaction of the supervisor. The progress of the project is evaluated based on a minimum of three reviews. The review committee is constituted by the Head of the Department. The project work is evaluated based on oral presentation and the project report, jointly by external and internal examiners. Technical Knowledge and skills

TOTAL :90 PERIODS

Course Outcomes :
On completion of the phase - 1 project work, the students will be able to
CO1 : Analyze and formulate the problem
CO2 :Identify the methodology needed to solve the problem.
CO3 :Identify the tools and techniques required to solve the problem.
CO4 :Work with team mates to acquire the required material needed to find solutions to the chosen problem.
CO5 :Effectively communicate the outcomes of the findings.

SEMESTER 4

JPX5461	Project Phase II	L	T	P	C
		0	0	24	12

Course Objectives :

1. To develop the ability to solve a specific problem related to their subject expertise.
2. To develop the methodology to solve the identified problem.
3. To design, analyze and implement the chosen problem using the hardware components.
4. To validate the simulation, hardware results with the theoretical results.
5. To train the students in preparing project reports and to face reviews and viva-voce examination.

Method of Evaluation:

The students in a group of 3 to 4 work on a topic approved by the Head of the Department under the guidance of a faculty member, prepare a comprehensive project report after completing the work to the satisfaction of the supervisor. The progress of the project is evaluated based on a minimum of three reviews. The review committee is constituted by the Head of the Department. The project work is evaluated based on oral presentation and the project report, jointly by external and internal examiners.

TOTAL: 270 PERIODS

Course Outcomes :

On Completion of the project work, the student will be able to

CO1 : Apply the technical knowledge acquired for solving real world problems.

CO2 : Develop skills such as self learning, critical thinking, problem solving, project management and finance.

CO3 : Apply modern tools and techniques.

CO4 : Work with team mates and collectively work towards the success of the project.

CO5 : Communicate effectively to present the outcomes of the project both in written and oral forms

PROFESSIONAL ELECTIVE - I (PE)

JPX5001	POWER SEMICONDUCTOR DEVICES	L	T	P	C
		3	0	0	3

Course Objectives:

1. To enable the students for the selection of devices for different power electronics applications
2. To understand the static and dynamic characteristics of current controlled power semiconductor devices
3. To understand the static and dynamic characteristics of voltage-controlled power semiconductor devices
4. To learn the firing and protection circuits for various power semiconductor devices
5. To acquire knowledge about wide bandgap devices.

Unit 1 INTRODUCTION TO SEMICONDUCTOR DEVICES **9**

Power switching devices overview – Attributes of an ideal switch, application requirements, circuit symbols; Power handling capability – (SOA); Device selection strategy – On-state and switching losses – EMI due to switching - switching loss calculation for power device - Power diodes - Types, forward and reverse characteristics, switching characteristics – rating.

Unit 2 CURRENT CONTROLLED DEVICES **9**

BJT's – Construction, static characteristics, switching characteristics; Negative temperature coefficient and second breakdown; Power Darlington- Thyristors – Physical and electrical principle underlying operating mode, concept of latching; Gate and switching characteristics; converter grade and inverter grade and other types; series and parallel operation; comparison of BJT and Thyristor – steady state and dynamic models of BJT &Thyristor- Basics of GTO, MCT, FCT, RCT

Unit 3 VOLTAGE CONTROLLED DEVICES **9**

Power MOSFETs and IGBTs – Principle of voltage controlled devices, construction, types, static and switching characteristics, steady state and dynamic models of MOSFET and IGBTs and IGCT. New semiconductor materials for devices - Integrated gate commutated thyristor (IGCT)- Comparison of all power devices

Unit 4 FIRING AND PROTECTION CIRCUITS 9

Necessity of isolation, pulse transformer, optocoupler – Gate drives circuit: SCR, MOSFET, IGBTs and base driving for power BJT. - Over voltage, over current and gate protections; Design of snubbers.

Unit 5 WIDE BANDGAP DEVICES 9

Features of silicon carbide and gallium nitride devices. SiC JFET- SiC MOSFET-GaN based transistors-Applications of SiC and GaN based devices.

Total : 45 Periods

Course Outcomes : At the end of the course, the student will be able

CO1 : To select the switching device suitable for the given application.

CO2 : To understand the principle and characteristics of current controlled devices.

CO3 : To understand the principle and characteristics of voltage controlled devices.

CO4 : To gain knowledge about firing and protection circuits of various devices.

CO5 : To acquire knowledge about wide bandgap devices.
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2. Rashid M.H., " Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Third Edition, New Delhi, 2004
3. MD Singh and K.B Khanchandani, "Power Electronics", Tata McGraw Hill, 2001.
4. Mohan, Undeland and Robins, "Power Electronics – Concepts, applications and Design, John Wiley and Sons, Singapore, 2000.
5. Joseph Vithayathil, Power Electronics: Principles and Applications, Delhi, Tata McGrawHill, 2010.
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CO-PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	2	1	1	2	1
CO 2	2	1	1	2	2	1
CO 3	2	1	1	2	2	2
CO4	1	2	1	2	1	1
CO5	1	2	1	2	1	1

JPX5002	**ELECTROMAGNETIC FIELD COMPUTATION AND MODELLING**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
Course Objectives :					
1.To refresh the fundamentals of Electromagnetic Field Theory					
2. To provide foundation in formulation and computation of Electromagnetic Fields using analytical and numerical methods.					
3. To impart knowledge in fundamentals of FEM					
4. To learn about the field quantities using FEM					
5. To get exposed with the design of electrical components					
Unit 1 INTRODUCTION TO ELECTROMAGNETIC FIELDS					**9**
Review of basic field theory – Maxwell's equations – Constitutive relationships and Continuity equations – Laplace, Poisson and Helmholtz equation – principle of energy conversion – force/torque calculation					

Unit 2 BASIC SOLUTION METHODS FOR FIELD EQUATIONS	**9**
Limitations of the conventional design procedure, need for the field analysis based design, problem definition, boundary conditions, solution by analytical methods-direct integration method – variable separable method – method of images, solution by numerical methods- Finite Difference Method - Moment Method - The Finite Element Method	
Unit 3 FORMULATION OF FINITE ELEMENT METHOD (FEM)	**9**
Variational Formulation – Energy minimization – Discretisation – Shape functions –Stiffness matrix – 1D and 2D planar and axial symmetry problems	
Unit 4 COMPUTATION OF BASIC QUANTITIES USING FEM PACKAGES	**9**
Basic quantities – Energy stored in Electric Field – Capacitance – Magnetic Field – Linked Flux – Inductance – Force – Torque – Skin effect – Resistance	
Unit 5 DESIGN APPLICATIONS	**9**
Design of Insulators –Magnetic actuators – Transformers – Rotating machines.	
	Total : 45 Periods
Course Outcomes : At the end of the course, the student will be able	
CO1: To understand the electromagnetic field theory concepts	
CO2: To formulate and compute Electromagnetic Fields using analytical and numerical methods.	
CO3: To funderstand about formulation of finite element method.	
CO4: To compute the respective field using FEM.	
CO5: To check and optimize the design of electrical power equipment	
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2. K.J.Binns, P.J.Lawrenson, C.W Trowbridge, “The analytical and numerical solution of Electric and magnetic fields”, John Wiley & Sons, 1993.	
3. Nicola Biyanchi, “Electrical Machine analysis using Finite Elements”, Taylor and Francis Group, CRC Publishers, 2005.	
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4. http://mooc.org/	
5. https://www.edx.org/	

CO-PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	1	1	2	1	1
CO 2	2	1	2	1	1	2
CO 3	2	2	1	2	2	1
CO4	1	1	2	1	2	2
CO5	2	1	1	1	2	1

JPX5003	**CONTROL SYSTEM DESIGN FOR POWER ELECTRONICS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Course Objectives :

1. To get exposed with modelling of DC to DC converters.
2. To Study sliding mode controller design for power electronic converters
3. To Study approximate linearization controller design
4. To impart knowledge on Nonlinear controller design
5. To explore the concepts of Predictive Control of Power Converters

Unit 1 MODELLING OF DC-TO-DC POWER CONVERTERS **9**

Modelling of Buck Converter , Boost Converter ,Buck-Boost Converter, Cuk Converter ,Sepic Converter, Zeta Converter, Quadratic Buck Converter ,Double Buck-Boost Converter, Boost- Boost Converter General Mathematical Model for Power Electronics Devices

Unit 2 SLIDING MODE CONTROLLER DESIGN **9**

Variable Structure Systems., Single Switch Regulated Systems - Sliding Surfaces, Accessibility of the Sliding Surface -Sliding Mode Control Implementation of Boost Converter ,Buck-Boost Converter, Cuk Converter ,Sepic Converter, Zeta Converter, Quadratic Buck Converter ,Double Buck-Boost Converter, Boost-Boost Converter

Unit 3 APPROXIMATE LINEARIZATION CONTROLLER DESIGN **9**

Linear Feedback Control, Pole Placement by Full State Feedback , Pole Placement Based on Observer Design ,Reduced Order Observers , Generalized Proportional Integral Controllers, Passivity Based Control , Sliding Mode Control Implementation of Buck Converter , Boost Converter ,Buck-Boost Converter

Unit 4 NONLINEAR CONTROLLER DESIGN **9**

Feedback Linearization Isidori's Canonical Form , Input-Output Feedback Linearization ,State Feedback Linearization, Passivity Based Control , Full Order Observers , Reduced Order Observers

Unit 5 PREDICTIVE CONTROL OF POWER CONVERTERS **9**

Basic Concepts, Theory, and Methods, Application of Predictive Control in Power Electronics, AC-DC-AC Converter System, Faults and Diagnosis Systems in Power Converters.

Total : 45 Periods

Course Outcomes : At the end of the course, the student will be able

CO1 To understand the modelling of DC to DC converters.

CO2 To understand and design the sliding mode controller for power electronic converters

CO3 To acquire knowledge on linear and nonlinear controller design

CO4 To gain knowledge on nonlinear controller design.
CO5 To understand about predictive control of power converters.
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1. Mahesh Patil, PankajRodey, "Control Systems for Power Electronics: A Practical Guide", Springer India, 2015.
2. Hebertt .J. Sira-Ramírez, Ramón Silva-Ortigoza, "Control Design Techniques in Power Electronics Devices", Springer 2012
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5. https://youtu.be/Xgnwn0G9qoo
6. https://youtu.be/B5gOHJkcBEc

CO-PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	1	2	1	1	2
CO 2	2	1	2	2	1	1
CO 3	2	1	2	1	2	2
CO4	2	1	1	2	1	1
CO5	2	1	2	1	2	1

JPX5004 ANALOG AND DIGITAL CONTROLLERS	L	T	P	C
	3	0	0	3

Course Objectives :

1. To provide an overview of the control system and converter control methodologies
2. To provide an insight to the analog controllers used in practice
3. To introduce about digital controllers
4. To study on the driving techniques, isolation requirements, signal conditioning and protection methods
5. To provide a Case Study by implementing an analog and a digital controller on a converter

Unit 1 CONTROL SYSTEM - OVERVIEW **9**

Feedback and Feed-forward control, Right Half Plane Zero, Gain margin and Phase Margin, Stability, Analysis and Transfer function of PI and PID controllers and its effects. Voltage mode control, Peak Current mode Control, Average Current mode Control for Converters – Need, advantages and disadvantages.

Unit 2 ANALOG CONTROLLERS **9**

Major components of a controller – Op-Amp based PI and PID controller – Proportional, Integral and Differential gains in terms of Resistance and Capacitance, Error Amplifiers, PWM generator using Ramp or Triangular generator and comparator, and Driver, Voltage mode controller design using UC3524, Peak Current mode controller design using UC3842, Average Current mode controller design using UC3854.

Unit 3 DIGITAL CONTROLLERS **9**

Basic digital control system-Pulse transfer function-Digital PID controller design-Micro Controllers and Digital Signal Controllers for Converter Control Application, Interface Modules for Converter Control – A/D, Capture, Compare and PWM, Analog Comparators for instantaneous over current detection, interrupts, Discrete PI and PID equations, Algorithm for PI and PID implementation, Example Code for PWM generation.

Unit 4 SIGNAL CONDITIONING, DRIVER, ISOLATION AND PROTECTION **9**

Voltage feedback sensing circuits, Hall effect sensors and Shunts for current feedback sensing, Low offset Op-Amps for signal conditioning, Single and dual supply op-amps, Totem pole drivers, Need for isolated drivers, Optically isolated drivers, low side drivers, high side drivers with bootstrap power supply, Vce sat sensing, CT based Device current sensing and pulse blocking.

Unit 5 CONTROLLER IMPLEMENTATION **9**

Analog and Digital Controller Design for Buck Converter – Power circuit transfer function and bode plot, PI controller bode plot, Combined bode plot with required Gain and Phase margins, compensator design using root locus-Implementation of Analog controller and Digital controller.

Total : 45 Periods

Course Outcomes : At the end of the course, the student will be able

CO1: To understand the control system and converter control methodologies

CO2: To analyze and design of analog controller

CO3: To analyze and design of Digital controller

CO4: To design of driver and protection circuit for converter

CO5: To implement the analog and digital controller for converter applications

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4. https://www.coursera.org/lecture/converter-control/9-1-2-introduction-PdOYc
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CO-PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	2	2	1	2	1
CO 2	2	1	1	1	2	1
CO 3	2	1	2	2	2	1
CO4	2	2	1	1	2	1
CO5	1	2	2	2	1	2

PROFESSIONAL ELECTIVE - II (PE)

JPX5005	**APPLIED SOFT COMPUTING**	**L T P C**
		3 0 0 3
Course Objectives :		
1. Get familiarized with different architectures and training algorithms of neural networks.		
2. Get exposed to the various neural modeling and control techniques with case study using simulation tool box.		
3. To impart knowledge on fuzzy set theory, fuzzy rules and fuzzy logic controller		
4. Get exposed with basics of evolutionary programs and Genetic Algorithm optimization technique		

5. To learn about hybrid control schemes and optimization algorithms with case study using simulation tool box.
Unit 1 ARTIFICIAL NEURAL NETWORK 9
Review of fundamentals – Biological neuron, artificial neuron, activation function, single layer perceptron – Limitation – Multi layer perceptron – Adaline and Madaline - Back propagation algorithm (BPA) – Recurrent neural network (RNN) – Adaptive resonance theory (ART) based network – Reinforcement learning.
Unit 2 NEURAL NETWORKS FOR MODELING AND CONTROL 9
Modelling of non-linear systems using ANN – Generation of training data – Optimal architecture– Model validation – Control of non-linear systems using ANN – Direct and indirect neuro control schemes – Adaptive neuro controller – Familiarization with neural network toolbox
Unit 3 FUZZY SET THEORY 9
Introduction to crisp sets and fuzzy sets- basic fuzzy set operation and approximate reasoning - fuzzy relation - Fuzzy membership functions - Introduction to fuzzy logic modeling and control - Fuzzification inferencing and defuzzification-Fuzzy knowledge and rule bases-Fuzzy modeling and control schemes for nonlinear systems. Self organizing fuzzy logic control- Fuzzy logic control for nonlinear time delay system.
Unit 4 GENETIC ALGORITHM 9
Evolutionary programs – Genetic algorithms, genetic programming and evolutionary programming - Genetic Algorithm versus Conventional Optimization Techniques - Genetic representations and selection mechanisms; Genetic operators- different types of crossover and mutation operators - Optimization problems using GA -Tabu search – Ant Colony Optimisation.
Unit 5 HYBRID CONTROL SCHEMES 9
Fuzzification and rule base using ANN – Neuro fuzzy systems – ANFIS – Fuzzy neuron– Optimization of membership function and rule base using Genetic Algorithm – Introduction to support vector machine – Particle swarm optimization – Case study – Familiarization with ANFIS toolbox
Total : 45 Periods
Course Outcomes : At the end of the course, the student will be able
CO1: To understand the overview of artificial neural network and training algorithms.
CO2: To analyze problems to formulate models and develop control schemes using Neuro controller systems
CO3: To design fuzzy controller for non-linear systems
CO4: To apply genetic algorithm for optimization applications.
CO5: To use modern IT tool boxes to simulate case studies
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2. Timothy J. Ross, "Fuzzy Logic with Engineering Applications", McGraw Hill Inc., 2000.
3. Goldberg, "Genetic Algorithm in Search, Optimization and Machine learning", Addison Wesley Publishing Company Inc. 1989
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CO - PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	2	2	1	2	2
CO 2	2	2	1	2	2	2
CO 3	2	2	1	1	2	1
CO4	2	2	1	2	2	2
CO5	2	2	2	1	2	1

JPX5006	**HIGH VOLTAGE DIRECT CURRENT TRANSMISSION**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
Course Objectives :					
1. To impart knowledge on operation, modelling and control of HVDC link.					
2. To impart knowledge on Thyristor based HVDC converters					
3. To provide basic concept of MTDC system.					
4. To perform steady state analysis of AC/DC system.					
5. To expose various HVDC simulators					
Unit 1	**DC POWER TRANSMISSION TECHNOLOGY**				**9**
Introduction - Comparison of AC and DC transmission – Application of DC transmission – Description of DC transmission system - Planning for HVDC transmission – Modern trends in DC transmission – DC breakers – Cables, VSC based HVDC.					
Unit 2	**THYRISTOR BASED HVDC CONVERTERS AND HVDC SYSTEM CONTROL**				**9**
Pulse number, choice of converter configuration – Simplified analysis of Graetz circuit - Converter bridge characteristics – characteristics of a twelve pulse converter- detailed analysis of converters. General principles of DC link control – Converter control characteristics – System control hierarchy - Firing angle control – Current and extinction angle control – Generation of harmonics and filtering - power control – Higher level controllers-Valve tests.					
Unit 3	**MULTITERMINAL DC SYSTEMS**				**9**
Introduction – Potential applications of MTDC systems - Types of MTDC systems - Control and protection of MTDC systems - Study of MTDC systems.					
Unit 4	**POWER FLOW ANALYSIS IN AC/DC SYSTEMS**				**9**

Per unit system for DC Quantities - Modelling of DC links - Solution of DC load flow - Solution of AC-DC power flow – Unified, Sequential and Substitution of power injection method
Unit 5 SIMULATION OF HVDC SYSTEMS
Introduction – DC LINK Modelling , Converter Modeling and State Space Analysis , Philosophy and tools – HVDC system simulation, Online and OFF line simulators — Dynamic interaction between DC and AC systems.
Total : 45 Periods
Course Outcomes : At the end of the course, the student will be able
CO1 : To gain knowledge on operation, modelling and control of HVDC link.
CO2 : To acquire knowledge on Thyristor based HVDC converters
CO3 : To understand the basic concept of MTDC system.
CO4 : To assess steady state analysis of AC/DC system.
CO5 : To review modelling of DC links and HVDC simulators.
REFERENCES :
1. K.R.Padiyar, , "HVDC Power Transmission Systems", New Age International (P) Ltd., New Delhi, 2002
2. V.K.Sood, HVDC and FACTS controllers – Applications of Static Converters in Power System, APRIL 2004 , Kluwer Academic Publishers
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CO-PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	**1**	2	1	1	2	2

CO 2	2	1	1	2	1	1
CO 3	1	2	2	1	2	1
CO4	1	2	2	1	1	2
CO5	1	2	2	2	1	1

JPX5007	**FLEXIBLE AC TRANSMISSION SYSTEMS**	**L T P C**
		3 0 0 3

Course Objectives :

1. To emphasis the need for FACTS controllers.
2. To learn the characteristics, applications and modelling of shunt FACTS controllers.
3. To learn the characteristics, applications and modelling of series FACTS controllers.
4. To learn the characteristics, applications and modelling of VSC based FACTS controllers
5. To study the interaction of different FACTS controller and perform control coordination

Unit 1 INTRODUCTION TO POWER TRANSMISSION NETWORKS **9**

Review of basics of power transmission networks-control of power flow in AC transmission line Analysis of uncompensated AC Transmission line- Passive reactive power compensation: Effect of series and shunt compensation at the mid-point of the line on power transfer- Need for FACTS controllers- types of FACTS controllers

Unit 2 STATIC VAR COMPENSATOR (SVC) **9**

Configuration of SVC- voltage regulation by SVC- Modelling of SVC for load flow analysisModelling of SVC for stability studies-Design of SVC to regulate the mid-point voltage of a SMIB system-Applications: transient stability enhancement and power oscillation damping of SMIB system with SVC connected at the mid-point of the line - SVC implementation example

Unit 3 THYRISTOR AND GTO CONTROLLED SERIES CAPACITORS(TCSC and GCSC) **9**

Concepts of Controlled Series Compensation – Operation of TCSC and GCSC- Analysis of TCSC-GCSC – Modelling of TCSC and GCSC for load flow studies- modeling TCSC and GCSC for stability studied- Applications of TCSC and GCSC - TCSC implementation example

Unit 4 VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS **9**

Static synchronous compensator(STATCOM)- Static synchronous series compensator(SSSC)-Operation of STATCOM and SSSC-Power flow control with STATCOM and SSSC- Modelling of STATCOM and SSSC for power flow and transient stability studies –operation of Unified and Interline power flow controllers(UPFC and IPFC)- Modelling of UPFC and IPFC for load flow and transient stability studies- Applications - STATCOM implementation example

Unit 5 CONTROLLERS AND THEIR COORDINATION **9**

FACTS Controller interactions – SVC–SVC interaction - co-ordination of multiple controllers using linear control techniques – Quantitative treatment of control coordination.

Total : 45 Periods

Course Outcomes : At the end of the course, the student will be able

CO1: To understand the need for FACTS systems

CO2: To understand, analyze and design SVC

CO3: To understand, analyze and design TCSC and GCSC

CO4: To understand, analyze and design VSC based FACTS controllers

CO5: To understand the coordination of various FACTS controllers

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1. R.Mohan Mathur, Rajiv K.Varma,"Thyristor–Based Facts Controllers for Electrical Transmission Systems", IEEE press andJohnWiley&Sons,Inc,2002.
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4. K.R. Padiyar, "FACTS Controllers in Power Transmission and Distribution", New Age International (P) Limited, Publishers, New Delhi, 2008
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CO-PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	**1**	2	1	1	1	1
CO 2	2	2	2	2	2	2
CO 3	1	1	1	1	1	1
CO4	2	2	2	2	2	1
CO5	1	1	1	1	1	2

JPX5008	**ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
Course Objectives :					
1. To provide fundamental knowledge on electromagnetic interference and electromagnetic compatibility.					
2. To expose on various grounding and cabling techniques					

3. To study the importance of balancing, filtering and shielding
4. To learn about EMI in elements and circuits
5. To impart knowledge on electrostatic discharge, standards and testing techniques.
Unit 1 INTRODUCTION TO ELECTROMAGNETIC INTERFERENCE 9
Definitions of EMI/EMC -Sources of EMI- Intersystems and Intrasystem- Conducted and radiated interference- Characteristics - Designing for electromagnetic compatibility (EMC)- EMC regulation typical noise path- EMI predictions and modeling, Cross talk - Methods of eliminating interferences.
Unit 2 GROUNDING AND CABLING 9
Cabling- types of cables, mechanism of EMI emission / coupling in cables –capacitive coupling inductive coupling- shielding to prevent magnetic radiation- shield transfer impedance, Grounding – safety grounds – signal grounds- single point and multipoint ground systems hybrid grounds- functional ground layout –grounding of cable shields- -guard shields- isolation, neutralizing transformers, shield grounding at high frequencies, digital grounding- Earth measurement Methods
Unit 3 BALANCING, FILTERING AND SHIELDING 9
Power supply decoupling- decoupling filters-amplifier filtering –high frequency filtering- EMI filters characteristics of LPF, HPF, BPF, BEF and power line filter design -Choice of capacitors, inductors, transformers and resistors, EMC design components -shielding – near and far fields shielding effectiveness- absorption and reflection loss- magnetic materials as a shield, shield discontinuities, slots and holes, seams and joints, conductive gaskets-windows and coatings - grounding of shields
Unit 4 EMI IN ELEMENTS AND CIRCUITS 9
Electromagnetic emissions, noise from relays and switches, non-linearity's in circuits, passive inter modulation, transients in power supply lines, EMI from power electronic equipment, EMI as combination of radiation and conduction
Unit 5 ELECTROSTATIC DISCHARGE, STANDARDS AND TESTING TECHNIQUES 9
Static Generation- human body model- static discharges- ESD versus EMC, ESD protection in equipments- standards – FCC requirements – EMI measurements – Open area test site measurements and precautions- Radiated and conducted interference measurements, Control requirements and testing methods
Total : 45 Periods
Course Outcomes : At the end of the course, the student will be able
CO1 : To recognize the sources of Conducted and radiated EMI in Power Electronic Converters and consumer appliances and suggest remedial measures to mitigate the problems
CO2 : To Understand the various grounding and cabling methods
CO3 : To acquire knowledge on the importance of balancing, filtering and shielding.
CO4: To understand about EMI in elements and circuits
CO5: To gain knowledge on electrostatic discharge, standards and testing techniques.
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CO-PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	2	2	1	1	2
CO 2	2	1	1	2	1	1
CO 3	1	1	2	1	2	2
CO4	2	1	1	1	2	1
CO5	1	1	2	1	2	2

PROFESSIONAL ELECTIVE - III (PE)

JPX5009 MODERN RECTIFIERS AND RESONANT CONVERTERS	L	T	P	C
	3	0	0	3

Course Objectives :

- To impart knowledge on the harmonic standards and operation of rectifiers in CCM &DCM
- To provide an overview about the pulse width modulated rectifiers and its applications
- To illustrate the concept of soft switching and resonant converters.
- To accord basic knowledge about dynamic analysis of DC-DC converter.
- To introduce the source current shaping methods for rectifier.

Unit 1 POWER SYSTEM HARMONICS & LINE COMMUTATED RECTIFIERS 9

Average power-RMS value of waveform–Effect of Power factor-. current and voltage harmonics – Effect of source and load impedance - AC line current harmonic standardsIEC1000-IEEE 519-CCM and DCM operation of single phase full wave rectifier-Behaviour of full wave rectifier for large and small values of capacitance - CCM and DCM operation of three phase full wave rectifier- 12 pulse converters - Harmonic trap filters.

Unit 2 PULSE WIDTH MODULATED RECTIFIERS 9

Properties of Ideal single phase rectifiers-Realization of nearly ideal rectifier-. Single-phase converter systems incorporating ideal rectifiers - Losses and efficiency in CCM high quality rectifiers -single-phase PWM rectifier -PWM concepts - device selection for rectifiers - IGBT based PWM rectifier, comparison with SCR based converters with respect to harmonic content -applications of rectifiers.

Unit 3 RESONANT CONVERTERS 9

Soft Switching - classification of resonant converters - Quasi resonant converters- basics of ZVS and ZCS- half wave and full wave operation (qualitative treatment)- multi resonant converters - operation and analysis of ZVS and ZCS multi resonant converter - zero voltage transition PWM converters -zero current transition PWM converters

Unit 4 DYNAMIC ANALYSIS OF SWITCHING CONVERTERS 9

Review of linear system analysis-State Space Averaging-Basic State Space Average Model State Space Averaged model for an ideal Buck Converter, ideal Boost Converter, ideal Buck Boost Converter and an ideal Cuk Converter. Pulse Width modulation - Voltage Mode PWM Scheme - Current Mode PWM Scheme - design of PI controller.

Unit 5 SOURCE CURRENT SHAPING OF RECTIFIERS 9

Need for current shaping - power factor - functions of current shaper - input current shaping methods - passive shaping methods -input inductor filter - resonant input filter - active methods - boost rectifier employing peak current control - average current control - Hysteresis control- Nonlinear carrier control.

Total : 45 Periods

Course Outcomes : At the end of the course, the student will be able
• To understand the operation various rectifiers in CCM and DCM.
• To analyze and design pulse width modulated rectifiers for vaious applications
• To understand the concept of soft switching and analyze and design the resonant converters.
• To gain knowledge on dynamic analysis of switching converters.
• To evaluate the need and effects of various source current shaping methods on the performance of rectifiers.
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CO-PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	1	1	2	2	1
CO 2	2	1	1	2	1	1
CO 3	1	1	2	1	1	2
CO4	2	1	1	2	2	1
CO5	1	1	2	1	2	2

JPX5010 ELECTRIC POWER QUALITY	L	T	P	C
	3	0	0	3

Course Objectives :

- To provide an overview about the characterization of electric power.
- To understand the concept of power and power factor in single phase and three phase systems supplying nonlinear loads.
- To To equip with required skills to design conventional compensation techniques for power factor correction and load voltage regulation.
- To introduce the control techniques for the active compensation.
- To understand the mitigation techniques using custom power devices such as DSTATCOM, DVR & UPQC.

Unit 1 INTRODUCTION TO POWER QUALITY 9

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 2ANALYSIS OF SINGLE PHASE AND THREE PHASE SYSTEM 9

Single phase sinusoidal, non sinusoidal source supplying linear and nonlinear loads – Three phase Balance system – Three phase unbalanced system – Three phase unbalanced and distorted source supplying non linear loads – Concept of PF – Three phase three wire –Three Phase four wire system.

Unit 3 CONVENTIONAL LOAD COMPENSATION METHODS 9

Principle of Load compensation and Voltage regulation – Classical load balancing problem : Open loop balancing – Closed loop balancing, Current balancing – Harmonic reduction and voltage sag reduction – Analysis of unbalance – instantaneous real and reactive powers – Extraction of fundamental sequence component.

Unit 4 LOAD COMPENSATION USING DSTATCOM 9

Compensating single phase loads – Ideal three phase shunt compensator structure – Generating reference currents using instantaneous PQ theory – Instantaneous symmetrical components theory – Generating reference currents when the source is unbalanced – Realization and control of DSTATCOM – DSTATCOM in Voltage control mode.

Unit 5 SERIES COMPENSATION OF POWER DISTRIBUTION SYSTEM 9

Rectifier supported Dynamic Voltage Restorer – DC Capacitor supported DVR – DVR Structure – voltage Restoration – Series Active Filter – Unified Power Quality Conditione**r**

Total : 45 Periods

Course Outcomes : At the end of the course, the student will be able

- To comprehend the consequences of Power Quality issues
- To conduct harmonic analysis of single phase and three phase systems supplying non-linear loads
- To design passive filter for load compensation.

• To design active filters for load compensation.
• To understand the mitigation techniques using custom power devices such as distribution static compensator (DSTATCOM), dynamic voltage restorer (DVR) & UPQC.
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CO-PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	1	1	2	2	1
CO 2	2	1	1	2	1	1
CO 3	1	1	2	1	1	2
CO4	2	1	1	2	2	1
CO5	1	1	2	1	2	2

JPX5011 SOLAR AND ENERGY STORAGE SYSTEMS	**L**	**T**	**P**	**C**
	3	**0**	**0**	**3**
Course Objectives :				
• To study the behavior of solar cells and interconnection of PV cells.				
• To impart knowledge on the power regulation of standalone systems.				
• To learn the performance of grid connected PV systems.				
• To provide an overview about various energy storage systems.				
• To familiarize with various applications of solar energy systems.				
Unit 1 INTRODUCTION TO PHOTOVOLTAIC SYSTEM 9				

Characteristics of sunlight – semiconductors and P-N junctions –behaviour of solar cells – cell properties – PV cell interconnection
Unit 2 STAND ALONE PV SYSTEM 9
Solar modules – storage systems – power conditioning and regulation - MPPT- protection – stand alone PV systems design – sizing
Unit 3 GRID CONNECTED PV SYSTEMS 9
PV systems in buildings – design issues for central power stations – safety – Economic aspect –Efficiency and performance - International PV programs
Unit 4 ENERGY STORAGE SYSTEMS 9
Impact of intermittent generation – Battery energy storage – solar thermal energy storage – pumped hydroelectric energy storage
Unit 5 APPLICATIONS 9
Water pumping – battery chargers – solar car – direct-drive applications –Space – Telecommunications.
Total : 45 Periods
Course Outcomes: At the end of the course, the student will be able
• To understand the working and interconnection of photovoltaic systems.
• To design and develop the power tracking algorithms for standalone system.
• To design and analyze the performance of grid connected PV systems.
• To acquire knowledge about the modeling of different energy storage systems and their performances.
• To pertain the knowledge on various applications of solar energy systems.
REFERENCES :
1. Solanki C.S., "Solar Photovoltaics: Fundamentals, Technologies And Applications", PHI Learning Pvt. Ltd.,2015.
2. Chetan Sigh Solanki, "Energy Swaraj My Exprement with Solar Truth", 2019,Notion press.
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CO-PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	2	1	2	2	1
CO 2	1	2	1	2	1	2
CO 3	1	1	2	1	1	2
CO4	2	1	1	1	2	1
CO5	1	1	2	1	2	2

JPX5012 WIND ENERGY CONVERSION SYSTEMS	**L**	**T**	**P**	**C**
	3	**0**	**0**	**3**

Course Objectives:

- To learn about the basic concepts of wind energy conversion system
- To learn the design and control principles of Wind turbine.
- To study the concepts of fixed speed wind energy conversion systems.
- To study the concepts of variable speed wind energy conversion systems.
- To familiarize with various grid integration issues.

Unit 1 INTRODUCTIONTO WIND ENERGY CONVERSION SYSTEMS 9

Components of WECS-WECS schemes-Power obtained from wind-simple momentum theory Power coefficient-Sabinin's theory-Aerodynamics of Wind turbine.

Unit 2 WIND TURBINES 9

HAWT-VAWT-Power developed-Thrust-Efficiency-Rotor selection-Rotor design considerations Tip speed ratio-No. of Blades-Blade profile-Power Regulation-yaw control-Pitch angle control stall control-Schemes for maximum power extraction.

Unit 3 FIXED SPEED SYSTEMS 9

Generating Systems- Constant speed constant frequency systems -Choice of Generators Deciding factors-Synchronous Generator-Squirrel Cage Induction Generator- Model of Wind Speed- Model wind turbine rotor - Drive Train model- Generator model for Steady state and Transient stability analysis.

Unit 4 VARIABLE SPEED SYSTEMS 9

Need of variable speed systems-Power-wind speed characteristics-Variable speed constant frequency systems synchronous generator- DFIG- PMSG -Variable speed generators modeling - Variable speed variable frequency schemes.

Unit 5 GRID CONNECTED SYSTEMS 9

Wind interconnection requirements, low-voltage ride through (LVRT), ramp rate limitations, and supply of ancillary services for frequency and voltage control, current practices and industry trends wind interconnection impact on steady-state and dynamic performance of the power system including modeling issue.

Total : 45 Periods

Course Outcomes : At the end of the course, the student will be able

- To acquire knowledge on the basic concepts of Wind energy conversion system.

• To understand the mathematical modelling and control of the Wind turbine.
• To design and develop Fixed speed wind energy conversion systems.
• To design and develop Variable speed wind energy conversion systems .
• To analyze various Grid integration issues and current practices of wind interconnections with power system.
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1. L.L.Freris "Wind Energy conversion Systems", Prentice Hall, 1990
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CO-PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	2	1	2	2	2
CO 2	2	2	1	2	1	2
CO 3	2	1	1	1	1	2
CO4	2	1	1	1	2	2
CO5	2	1	1	1	2	2

PROFESSIONAL ELECTIVE - IV (PE)

JPX5013 SMPS AND UPS	L	T	P	C
	3	0	0	3

Course Objectives :

- To learn the modeling of various DC to DC converters.
- To provide an overview on the state space model and control circuitry for switching mode power converters.
- To familiarize with the concepts of Resonant converters.
- To study the principle and control aspects of various DC- AC converters.
- To learn the design and control principles of power conditioners and filters.

Unit 1 DC-DC CONVERTERS **9**

Principles of stepdown and stepup converters – Analysis and state space modeling of Buck, Boost, Buck- Boost and Cuk converters.

Unit 2SWITCHING MODE POWER CONVERTERS **9**

Analysis and state space modeling of flyback, Forward, Luo, Half bridge and full bridge converters- control circuits and PWM techniques.

Unit 3 RESONANT CONVERTERS **9**

Introduction- classification- basic concepts- Resonant switch- Load Resonant converters- ZVS , Clamped voltage topologies- DC link inverters with Zero Voltage Switching- Series and parallel Resonant inverters- Voltage control .

Unit 4 DC-AC CONVERTERS **9**

Single phase and three phase inverters, control using various (sine PWM, SVPWM and advanced modulation) techniques, various harmonic elimination techniques- Multilevel inverters- Concepts - Types: Diode clamped- Flying capacitor- Cascaded types- Applications.

Unit 5 POWER CONDITIONERS, UPS & FILTERS **9**

Introduction- Power line disturbances- Power conditioners –UPS: offline UPS, Online UPS, Solar Powered UPS, Configuration- online double conversion, line-interactive and offline, Applications – Filters: Voltage filters, Series-parallel resonant filters, filter without series capacitors, filter for PWM VSI, current filter, DC filters – Design of inductor and transformer for PE applications – Selection of capacitors.

Total : 45 Periods

Course Outcomes : At the end of the course, the student will be able

- To design and model various DC to DC Converters for variable DC generation.
- To develop the state space model and control circuitry for switching mode power converters.
- To design and develop the Resonant converters.
- To acquire knowledge on the design and control of DC to AC Converters.
- To select and design the power conditioners and filters.

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CO-PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	1	1	2	2	2
CO 2	2	1	1	2	1	2
CO 3	2	1	1	2	1	2
CO4	2	1	1	2	2	2
CO5	2	1	1	1	2	2

JPX5014 POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS	**L**	**T**	**P**	**C**
	3	**0**	**0**	**3**

Course Objectives :

- To provide an overview on power generation using various renewable energy sources.
- To study the principle and working of electrical machines used for renewable energy applications.
- To comprehend the various operating modes of power electronic converters used for solar energy systems.
- To learn the operating modes of power electronic converters used for wind energy conversion systems.
- To illustrate the need for hybrid systems and maximum power point tracking algorithms.

Unit1 INTRODUCTION TO RENEWABLE ENERGY SYSTEM 9

Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (cost-GHG Emission)-Qualitative study of different renewable energy resources ocean, Biomass, Hydrogen energy systems: operating principles and characteristics of: Solar PV, Fuel cells, wind electrical systems-control strategy, operating area.

Unit 2 ELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION 9

Review of reference theory fundamentals-principle of operation and analysis: IG, PMSG, SCIG and DFIG.

Unit 3 POWER ELECTRONICS FOR SOLAR SYSTEM 9
Block diagram of solar photo voltaic system : line commutated converters (inversion-mode)-Boost and buck-boost converters-selection of inverter, battery sizing, array sizing- standalone PV systems - Grid tied and grid interactive inverters- grid connection issues.
Unit 4 POWER ELECTRONICS FOR WIND ENERGY CONVERSION SYSTEM 9
Three phase AC voltage controllers-AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, matrix converters- Stand alone operation of fixed and variable speed wind energy conversion systems- Grid connection Issues -Grid integrated PMSG and SCIG Based WECS.
Unit 5 HYBRID RENEWABLE ENERGY SYSTEMS 9
Need for Hybrid Systems -Range and type of Hybrid systems-Case studies of Wind-PV Maximum Power Point Tracking (MPPT).
Total : 45 Periods
Course Outcomes :At the end of the course, the student will be able
• To understand the impacts of renewable energy generation on environment.
• To design and analyze the machines for renewable energy generation.
• To design and develop the power electronic converters of solar energy system.
• To design and analyze power electronic converters used for wind energy conversion systems
• To develop hybrid systems and algorithms for maximum power point tracking algorithms
REFERENCES :
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CO-PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	1	2	1	2	2
CO 2	1	2	1	2	1	1
CO 3	1	1	2	1	1	2
CO4	1	2	1	2	2	1
CO5	1	1	2	1	2	2

JPX5015 NON LINEAR DYNAMIC FOR POWER ELECTRONICS CIRCUITS	**L T P C**
	3 0 0 3
Course Objectives :	
• To study the non linear behavior of power electronic converters.	
• To learn the techniques for investigation on non linear behaviour of power electronic converters.	
• To provide an overview on nonlinear phenomena in DC to DC converters.	
• To familiarize with nonlinear phenomena in AC and DC Drives.	
• To introduce the control techniques for control of non linear behavior in power electronic systems.	
Unit 1 BASICS OF NONLINEAR DYNAMICS	**9**
Basics of Nonlinear Dynamics: System, state and state space model, Vector field- Modelling of Linear, nonlinear and Liberalized systems, Attractors , chaos, Poincare map, Dynamics of Discrete time system, Lyapunov Exponent, Bifurcations, Bifurcations of smooth map, Bifurcations in piece wise smooth maps, border crossing and border collision bifurcation.	
Unit 2TECHNIQUES FOR INVESTIGATION OF NONLINEAR PHENOMENA	**9**
Techniques for experimental investigation, Techniques for numerical investigation, Computation of averages under chaos, Computations of spectral peaks, Computation of the bifurcation and analyzing stability.	
Unit 3 NONLINEAR PHENOMENA IN DC-DC CONVERTERS	**9**
Border collision in the Current Mode controlled Boost Converter, Bifurcation and chaos in the Voltage controlled Buck Converter with latch, Bifurcation and chaos in the Voltage controlled Buck Converter without latch, Bifurcation and chaos in Cuk Converter. Nonlinear phenomenon in the inverter under tolerance band control	
Unit 4 NONLINEAR PHENOMENA IN DRIVES	**9**
Nonlinear Phenomenon in Current controlled and voltage controlled DC Drives, Nonlinear Phenomenon in PMSM Drives.	
Unit 5 CONTROL OF CHAOS	**9**

Hysteresis control, Sliding mode and switching surface control, OGY Method, Pyragas method, Time Delay control. Application of the techniques to the Power electronics circuit and drives.
Total : 45 Periods
Course Outcomes :At the end of the course, the student will be able
• To analyze the techniques for investigation on non linear behaviour of power electronic converters.
• To understand the non linear behavior of power electronic converters
• To gain knowledge on nonlinear phenomena in DC to DC converters.
• To understand the nonlinear phenomena in AC and DC Drives.
• To mitigate chaotic behavior noticed in power system
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CO-PO MAPPING :

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CO 1	1	1	2	1	2	2
CO 2	1	1	1	1	1	1
CO 3	1	1	2	2	1	1
CO4	1	1	1	1	2	1
CO5	1	1	2	1	2	2

JPX5016 ENERGY MANAGEMENT AND AUDITING	**L**	**T**	**P**	**C**
	3	**0**	**0**	**3**
Course Objectives :				
• To study the present energy scenario and role of energy managers				
• To provide an overview about economic models for cost and load management.				
• To impart knowledge on the demand side energy management through its control techniques, strategy and planning.				

- To learn the process of energy auditing.
- To familiarize with energy conservation technologies.

Unit 1 ENERGY SCENARIO9

Basics of Energy and its various forms - Conventional and non-conventional sources - Energy policy - Energy conservation act 2001, Amendments (India) in 2010 - Need for energy management- Designing and starting an energy management program - Energy managers and energy auditors - Roles and responsibilities of energy managers - Energy labelling and energy standards.

Unit 2ENERGY COST AND LOAD MANAGEMENT9

Important concepts in an economic analysis - Economic models-Time value of money-Utility rate structures- cost of electricity-Loss evaluation- Load management: Demand control techniques-Utility monitoring and control system-HVAC and energy management-Economic justification.

Unit 3 ENERGY MANAGEMENT 9

Demand side management (DSM)– DSM planning – DSM techniques – Load management as a DSM strategy – Energy conservation – Tariff options for DSM.

Unit 4 ENERGY AUDITING 9

Definition – Energy audit methodology: audit preparation, execution and reporting – Financial analysis – Sensitivity analysis – Project financing options - Instruments for energy audit – Energy audit for generation, distribution and utilization systems – Economic analysis.

Unit 5 ENERGY EFFICIENT TECHNOLOGIES 9

Energy saving opportunities in electric motors - Power factor improvement benefit and techniques Shunt capacitor, Synchronous Condenser and Phase Advancer - Energy conservation in industrial drives, electric furnaces, ovens and boilers - Lighting techniques: Natural, CFL, LED lighting sources and fittings.

Total : 45 Periods

Course Outcomes :At the end of the course, the student will be able

- To understand the present energy scenario and role of energy managers.
- To comprehend the economic models for cost and load management.
- To configure the demand side energy management through its control techniques, strategy and planning.
- To understand the process of energy auditing.
- To implement energy conservation aspects in industries.

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1. Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, “Guide to Energy Management”, Eighth Edition, River Publication, 2020

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CO-PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	1	2	1	2	2
CO 2	2	2	1	1	1	1
CO 3	1	1	2	2	1	2
CO4	2	2	1	1	2	1
CO5	1	1	2	1	2	2

OPEN ELECTIVE (OE)

JPX9001 INTELLIGENT SENSORS FOR ENGINEERING APPLICATIONS	L	T	P	C
	3	0	0	3
Course Objectives :				
• To study the principle of sensors and their characteristics.				
• To impart the concepts of mechanical and electromechanical sensors.				
• To learn about thermal, Radiation and magnetic sensors.				
• To study the various electro-analytical sensors and get introduced to smart sensors.				
• To get exposed to the recent trends in sensors and their applications in various fields.				
Unit 1 SENSORS AND THEIR CHARACTERISTICS				**9**
Sensors - Principle, Classification, Parameters, Static Characteristics and Dynamic characteristics - Characterization: Electrical, Mechanical, Thermal, Optical and Chemical.				
Unit 2 MECHANICAL AND ELECTROMECHANICAL SENSORS				**9**
Construction and working of Piezoelectric Sensors – Force/stress sensor – Ultrasonic sensors – Resistive Sensors: Potentiometer, Stain Gauges- Inductive sensors: Ferromagnetic type, Transformer type – Capacitive Sensors: Parallel plate type, Variable permittivity type.				
Unit 3 THERMAL , RADIATION AND MAGNETIC SENSORS				**9**
Construction and working of Thermal Sensors – Gas Thermometric sensors, Thermal expansion sensors – Radiation Sensors – Photo resistors, Photovoltaic cells, Fibre Optic Sensors – Magnetic Sensors – Hall Effect sensor, Eddy Current sensors.				
Unit 4 ELECTROANALYTICAL AND SMART SENSORS				**9**
Construction and working of Analytical sensors – Standard Hydrogen Electrodes, Reference Electrodes – Smart Sensors – Introduction – Primary sensors, Excitation, Amplification, Filters, Converters, Compensation, Information Processing.				
Unit 5 RECENT TRENDS IN SENSORS				**9**
Basic concepts of Film Sensors, Micro Electro Mechanical Systems (MEMS), Nano Sensors – Applications: On-board Automobile sensors – Environmental monitoring sensors – Temperature and Pressure Sensors used in IoT applications – RFID sensors – Biometric sensors- Sensors for health and agricultural applications.				
Total : 45 Periods				
Course Outcomes : At the end of the course, the student will be able				
• To explain the static and dynamic characteristics of a sensor.				
• To understand the concepts behind mechanical and electromechanical sensors.				
• To apply and gain knowledge about thermal, radiation and magnetic sensors.				
• To demonstrate about the electro analytical sensors and smart sensors.				

- To assess the recent trends in sensor technology and their applications in various fields.

Text Book:

1. D.A Hall, "Sensors and Actuators ", CRC press, 18th August, 2020.

2. Rengananthan.S, "Transducer Engineering", Allied Publishers (P) Ltd, 2003.

3. Neubert H.K.P., " Instrument Transducers – An Introduction to their Performance and Design", Oxford University Press, Cambridge, 2003.

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1. Bela. G.Liptak, "Instrument Engineers, Handbook, Process Measurement and Analysis", 4th Edition, Vol. 1, ISA/CRC Press, 2003.

2. Doebelin E.O. and Manik D.N., "Measurement Systems Application and Design", International student Edition, 6th Edition, McGraw-Hill Education Pvt. Ltd., 2011.

3. John P. Bentley, "Principles of Measurement Systems", III Edition, Pearson Education, 2000.

4. Bradley.D.A and Dawson,Burd and Loader, "Mechatronics", Thomson Press India Ltd,2004.

5. Murthy, D.V.S., "Transducers and Instrumentation", 2nd Edition, Prentice Hall of India, Pvt. Ltd., New Delhi, 2010.

6. Ian Sinclair, "Sensors and Transducers", 3rd Edition, Elsevier, 2012.

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JPX 9002 SAFETY ENGINEERING AND MAINTENANCE L T P C

3 0 0 3

Course Objectives :

- To expose the students to electrical hazards
- To impart knowledge on prevention of electrical shocks
- To create awareness about various first aid methods
- To impart knowledge on Electrical safety in hazardous areas
- To study about Electrical safety management

Unit 1 INTRODUCTIONTO ELECTRICAL SAFETY 9

General Background-Objectives of safety and security measures-Hazards associated with electric current and voltage-principles of electrical safety- Approaches to Prevent Accidents Fire Prevention and Fire Fighting-Objectives and scope of IE act and IE rules-General requirements for electrical safety as per IE rules.

Unit 2 ELECTRICAL SHOCKS AND THEIR PREVENTION	**9**
Primary and Secondary Electric Shocks- Occurrence of Electric Shock -Shocks Due to Flashovers/Spark-overs- Lightning Strokes on Overhead Transmission Lines and Outdoor Substations - Safety Precautions in Small LV Installations, Residential Buildings, Shops - Safety Procedures in Electrical Plant Installation and description of Earthing System Equipment Earthing - Substation Earthing.	
Unit 3 FIRST AID	**9**
Introduction- Removal of Contact with Live Conductor- First Principles of Actions after Electric Shock - Artificial Respiration - Schafer's Prone Pressure Method- Silvester's Method Nielson's Arm-lift Back-pressure Method- Mouth to Mouth Method- Use of Artificial Resuscitator- External Cardiac Massage- Cardiac Pulmonary Resuscitation-First aid treatment of Heat Exhaustion and heat stroke.	
Unit 4 ELECTRICAL SAFETY IN HAZARDOUS AREAS	**9**
Introduction-Classification of Hazardous zones-causes of sparks and flashovers in electrical plants and machines-functional requirements of electrical equipment and installations for hazardous area/zones-classification of equipment/enclosure for hazardous locations.	
Unit 5 ELECTRICAL SAFETY MANAGEMENT	**9**
Introduction-Principles of safety management-management's safety policy-safety organization-organization charts for construction phase of a project, maintenance mode of a plant and for safety department – safety auditing-training and supervision-annual reports - motivation to managers, supervisors and employees.	
	Total : 45 Periods
Course Outcomes : At the end of the course, the student will be able	
• To understand electrical safety, IE act and IE rules.	
• To acquire knowledge on prevention of electrical shocks.	
• To acquire knowledge about various first aid measures.	
• To familiarize with electrical safety in hazardous areas.	
• To understand about maintenance and electrical safety management.	
REFERENCES :	
1. Das, Aklilkumar," Principles of Fire safety Engineering", PHI Learning Pvt. Ltd, 2020.	
2. S. Rao ,R.K.Jain and H.L. Saluja, "Electrical Safety, Fire Safety and Safety Management", Khanna Publishers, Second Edition, 2012.	
3. W.F. Cooper, "Electrical Safety Engineering", Butterworth and Company, London, Third Edition, 2013	
4. J. Cadick, D. Neitzel and A. Winfield, "Electrical Safety Hand Book", McGraw Hill Education, Fourth Edition 2012.	
5. J. Maxwell Adams, "Electrical Safety- A Guide to the Causes and Prevention of Electric Hazards", The Institution of Electric Engineers, First Edition 3rd Reprint, 2009.	
6. Martha J. Boss and Gayle Nicoll, "Electrical Safety - Systems, Sustainability and Stewardship", CRC Press, First Edition, 2015.	

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JPX 9003 SMPS AND UPS FOR COMPUTER APPLICATIONS	**L T P C**
	3 0 0 3
Course Objectives :	
• To familiarize with the operation and characteristics of power semiconductor devices.	
• To study about various modes of operation of DC-DC Converters.	
• To learn the operation of isolated Switched Mode Power Supply	
• To provide an overview on the control aspects of converters	
• To impart knowledge on various components of SMPS for computer systems	
Unit 1 POWER SEMICONDUCTOR DEVICES	**9**
Layer diagram, Static and switching characteristics of BJT, MOSFET and IGBT - Layer diagram, V-I characteristics, turn on and turn off mechanisms of SCR.	
Unit 2 BASIC CONVERTER CIRCUITS	**9**
Principle, modes of operation, performance parameters and characteristics of Buck Regulator, Boost Regulator, Buck- Boost Regulator and Resonant Converters.	
Unit 3 ISOLATED SMPS	**9**
Principle, modes of operation and characteristics of Fly back Converter, Forward Converter, Bridge converters, Push-Pull Converter and SMPS with multiple outputs.	
Unit 4 CONTROL ASPECTS	**9**
Voltage Mode Control of SMPS- Current Mode Control of SMPS - PWM Controllers, Isolation in feedback loop - Power Supplies with multiple output.	
Unit 5 DESIGN CONSIDERATIONS AND APPLICATIONS	**9**
Selection of output filter capacitor, energy storage inductor, Switches- Design of Snubber circuits, High Frequency Inductor and high frequency Transformer - power supplies for portable electronic gadgets.	
	Total : 45 Periods
Course Outcomes : At the end of the course, the student will be able	
• To understand the operations and characteristics of various power semiconductor devices	

- To understand various modes of operation of DC-DC converters.
- To gain knowledge about isolated SMPS system
- To acquire knowledge about various control aspects of converters
- To design various components of SMPS for computer systems

Text Books:

1. H. W. Whittington, B. W. Flynn and D. E. MacPherson "Switched Mode Power Supplies, Design and Construction", , Universities Press, 2009 Edition.

2. Mohan N. Undeland . T & Robbins W., "Power Electronics Converters, Application and Design", John Wiley, 3rd edition, 2002

3. Umanand L., Bhat S.R., "Design of magnetic components for switched Mode Power Converters", Wiley Eastern Ltd.,1992

REFERENCES :

1. Robert W. Erickson and Dragon Maksimovic, "Fundamentals of Power Electronics",Third Edition, Springer science and Business media, 2020.

2. V. Ramanarayanan "Course Material on Switched Mode Power Conversion"..

3. Sanjaya Maniktala – "Switching power supplies A to Z" – 1st edition 2006, Elsevier Inc.

4. Daniel M Mitchell : "DC-DC Switching Regulator Analysis", McGraw Hill Publishing Company

5. Ned Mohan et.al : "Power Electronics", John Wiley and Sons.

6. OtmarKilgenstein : "Switched Mode Power Supplies in Practice", John Wiley and Sons. N.P.Padhy, " Artificial Intelligence and Intelligent Systems", Oxford, 2013.

7. William S.Levine, "Control System Advanced Methods," The Control Handbook.CRC Press 2011.

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JPX9004 FUNDAMENTALS OF NANO SCIENCE	**L**	**T**	**P**	**C**
	3	**0**	**0**	**3**

Course Objectives :

- To learn about basics of Nano-material science

- To study the general preparation methods.
- To educate about various Nano materials.
- To educate about various characterization techniques
- To learn about the application of Nano material

Unit 1 INTRODUCTION TO NANO SCIENCE 9

Nano-scale Science and Technology- Implications for Physics, Chemistry, Biology and Engineering Classifications of Nano-structured materials- Nano particles- quantum dots, Nano wires-ultra-thin films multilayered materials. Length Scales involved and effect on properties: Mechanical, Electronic, Optical, Magnetic and Thermal properties. Introduction to properties and motivation for study (qualitative only).

Unit 2 GENERAL METHODS OF PREPARATION 9

Bottom-up Synthesis-Top-down Approach: Co-Precipitation, Ultrasonication, Mechanical Milling, Colloidal routes, Self-assembly, Vapour phase deposition, MOCVD, Sputtering, Evaporation, Molecular Beam Epitaxy, Atomic Layer Epitaxy, MOMBE

Unit 3 NANOMATERIALS 9

Nano forms of Carbon - Buckminster fullerene- graphene and carbon nano tube, Single wall carbon Nano tubes (SWCNT) and Multi wall carbon Nano-tubes (MWCNT)- methods of synthesis(arc-growth, laser ablation, CVD routes, Plasma CVD), structure-property Relationships applications- Nano metal oxides-ZnO, TiO2,MgO, ZrO2, NiO, Nano alumina, CaO, AgTiO2, Ferrites, Nano clays functionalization and applications-Quantum wires, Quantum dots-preparation, properties and applications.

Unit 4 CHARACTERIZATION TECHNIQUES 9

X-ray diffraction technique, Scanning Electron Microscopy - environmental techniques, Transmission Electron Microscopy including high-resolution imaging, Surface Analysis techniques- AFM, SPM, STM, SNOM, ESCA, SIMS-Nano indentation.

Unit 5 APPLICATIONS 9

Nano InfoTech: Information storage- nano computer, molecular switch, super chip, nano crystal, Nano biotechlogy: nanoprobes in medical diagnostics and biotechnology, Nano medicines, Targetted drug delivery, Bioimaging - Micro Electro Mechanical Systems (MEMS), Nano Electro Mechanical Systems (NEMS)- Nanosensors, nano crystalline silver for bacterial inhibition, Nano particles for sun barrier products - In Photostat, printing, solar cell, battery- application in food industries.

Total : 45 Periods

Course Outcomes : At the end of the course, the student will be able

- To understand the nano-scale science and technology
- To demonstrate the preparation of Nano materials
- To gain knowledge about various nano materials available in market.
- To develop knowledge in various characterization techniques

- To get idea about the areas of utilization of nano materials.

Textbooks :

1. A.S. Edelstein and R.C. Cammearata, eds., "Nanomaterials: Synthesis, Properties and Applications", Institute of Physics Publishing, Bristol and Philadelphia, 1996.

2. N John Dinardo, "Nanoscale Charecterisation of surfaces & Interfaces", 2nd edition, Weinheim Cambridge, Wiley-VCH, 2000.

3. G Timp, "Nanotechnology", AIP press/Springer, 1999.

4. AkhleshLakhtakia,"The Hand Book of Nano Technology, Nanometer Structure, Theory,Modeling and Simulations". Prentice-Hall of India (P) Ltd, New Delhi, 2007.

5. S.M. LINDSAY, "Introduction to Nanoscience" Oxford University Press,2010.

Reference :

1. Debora Berti, Gerardo Palazzo, "Colloidal Foundations of Nanoscience ", ElseverScience, 24 October 2021

2. William A. Goddard, III , Donald W. Brenner, Sergey Edward Lyshevski and Gerald J. Iafrate "Handbook of NANOSCIENCE,ENGINEERING,and TECHNOLOGY".,CRC Press, 2003.

3. Hans-Eckhardt Schaefer ,"Nanoscience", Springer, 2010.

4. P. Boisseau, P.Houdy and M. Lahmani, " Nanoscience" , Springer, 2010.

5. C. Dupas, PHoudy and M. Lahmani "Nanoscience" Springer,2007

6. Sengupta, Amretashis, Sarkar and Chandan Kumar," Introduction to Nano"", Springer, 2015

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JPX9005	**MEMS TECHNOLOGY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Course Objectives :

- To learn the properties of materials, microstructure and fabrication methods.
- To study the design and modeling of Electrostatic sensors and actuators.
- To provide an overview about the principle and fabrication of thermal sensors and actuators.
- To learn the principle and characteristics of piezoelectric sensors and actuators.

- To study the applications of various MEMS sensors and actuators

Unit 1 MICRO-FABRICATION, MATERIALS AND ELECTRO-MECHANICAL CONCEPTS 9

Overview of micro fabrication – Properties of silicon: Crystal structure – Orientation effects-Silicon and other material based fabrication processes – Concepts: Conductivity of semiconductors-Crystal planes and orientation-stress and strain-flexural beam bending analysis-torsional deflections-Intrinsic stress- resonant frequency and quality factor.

Unit 2 ELECTROSTATIC SENSORS AND ACTUATION 9

Principle, material, design and fabrication of parallel plate capacitors as electrostatic sensors and actuators-Applications

Unit 3 THERMAL SENSING AND ACTUATION 9

Thermal effects: Temperature coefficient of resistance -Principle, material, design and fabrication of thermal couples, thermal bimorph sensors, thermal resistor sensors-Applications.

Unit 4 PIEZOELECTRIC SENSING AND ACTUATION 9

Piezoelectric effect-cantilever piezoelectric actuator model-properties of piezoelectric materials- Applications.

Unit 5 CASE STUDIES 9

Electromechanical effects: Piezo resistance – Piezoelectricity - Piezo resistive sensors, Magnetic actuation, Micro fluidics applications, Medical applications, Optical MEMS.-NEMS Devices

Total : 45 Periods

Course Outcomes : At the end of the course, the student will be able

- To understand basics of micro fabrication, develop models and simulate electrostatic and electromagnetic sensors and actuators.
- To design and model the Electrostatic sensors and actuators.
- To design and fabricate the thermal sensors and actuators.
- To design and develop the piezoelectric sensors and actuators.
- To familiarize with the applications of various MEMS devices.

Reference Books :

1. Horst Theuss, Markku Tilli, Matthias Petzold, MerviPaulasto-Krockel, TeruakiMotooka, VeikkoLindroos, " Handbook of Silicon Based MEMS Materials and Technologies", ElseverScience, 17 April 2020.

2. Chang Liu, “Foundations of MEMS”, Pearson International Edition, 2006.

3. Marc Madou , “Fundamentals of microfabrication”,CRC Press, 1997.

4. Boston , “Micromachined Transducers Sourcebook”,WCB McGraw Hill, 1998.

5.M.H.Bao “Micromechanical transducers :Pressure sensors, accelerometers and gyroscopes”, Elsevier, Newyork, 2000.

6. Vikas Choudhary, "MEMS: Fundamental Technology and Application, CRC press, 2013.

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3. https://www.youtube.com/watch?v=JJElLA8k6Qg
4. https://nptel.ac.in/courses/108/108/108108147/
5. https://nptel.ac.in/courses/117/105/117105082/

JPX9006 POWER PLANT ENGINEERING	L	T	P	C
	3	0	0	3

Course Objectives :

- To study about various power generation methods.
- To learn various electrical and non-electrical parameters in power plant
- To impart knowledge about the different types of analyzers used in power plant.
- To provide an overview on the different control loops in boiler.
- To educate on turbine control techniques

Unit 1 OVERVIEW OF POWER GENERATION **9**

Survey of methods of power generation : hydro, thermal, nuclear, solar and wind power –

Importance of instrumentation in power plant.

Unit 2 MEASUREMENTS IN POWER PLANTS **9**

Electrical parameters: current, voltage, power, frequency, Non electrical parameters: flow of feed water, fuel, air, steam pressure and steam temperature – Turbine speed and vibration measurement.

Unit 3 ANALYZERS IN POWER PLANTS **9**

Flue gas oxygen analyzer – CO_2 analyzer – dissolved oxygen analyzer – chromatography – pH meter – fuel analyzer –smoke detector – dust monitor – CCTV – Pollution monitoring instruments.

Unit 4 CONTROL LOOPS IN BOILER **9**

Basic control loops – Steam Temperature control – Steam Pressure control – combustion control – air & fuel control – furnace draft control – drum level measurement and control – soot blowing.

Unit 5 CONTROL OF TURBINE **9**

Turbine governing system – Speed and Load control – Free governor mode operation – Automatic Load Frequency Control – Turbo-alternator cooling system.

Total : 45 Periods

Course Outcomes : At the end of the course, the student will be able

- To understand about various power generation process.
- To identify various electrical and non-electrical parameters in power pla
- To identify the purpose of analyzers in power plant.

• To assess and gain knowledge about various control loops in boiler
• Todesign and develop various turbine control techniques.
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1.ZarkBedalov, "Practical Power Plant Engineering A Guide for Early Career Engineers", Wiley Publication, 24 January 2020.
2. Sam G. Dukelow, "The control of Boilers", instrument Society of America, 1991.
3. Krishnaswamy KM, Bala P, Bala MP, "Power Plant Instrumentation", Prentice Hall, 2013
4. Modern Power Station Practice, Vol.6, "Instrumentation, Controls and Testing", Pergamon Press, Oxford, 1971.
5. Elonka.S.M.andKohal A.L., "Standard Boiler Operations", McGraw-Hill, New Delhi, 1994.
6. Jain R.K., "Mechanical and industrial Measurements", Khanna Publishers, New Delhi, 2008.
7. Tamilmani, "Power plant instrumentation", Sams Publishers, 2011.
8. Nag P.K., "Powerplant Engineering", Tata McGraw-Hill Education, 3rd edition, 2007.
9. Liptak B.G., "Instrumentation in Process Industries", Chilton Book Company, 2005.
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4. https://nptel.ac.in/courses/108/108/108108147/
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