DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

ANNA UNIVERSITY, CHENNAI – 25

VISION OF THE DEPARTMENT

The vision of Anna University is to be a world class institution by producing professionals with high technical knowledge, professional skills and ethical values, and remain as a preferred partner to the industry and community for their economic and social development through excellence in teaching, research and consultancy. Anna University shall be recognized as a point of reference, a catalyst, a facilitator, a trend setter and a leader in technical education.

MISSION OF THE DEPARTMENT

To produce full fledged Electrical and Electronics Engineers to cater to the needs of the modern industries and be useful for building the nation.

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UNIVERSITY DEPARTMENTS
REGULATIONS - 2019
CHOICE BASED CREDIT SYSTEM

M.E. POWER ELECTRONICS AND DRIVES

1. PROGRAMME EDUCATIONAL OBJECTIVES (PEOs) :

i. To prepare the students for successful career in electrical power industry, research and teaching institutions.
ii. To analyze power electronic supply/ machine drive problems.
iii. To design and develop the power electronic converter/drive systems.
iv. To develop the ability to analyze the dynamics in power electronic converters/drives systems
v. To introduce them to the sustainable energy generation technologies.
vi. To promote student awareness for the lifelong learning and introduce them to professional ethics.

2. PROGRAMME OUTCOMES (POs):

On successful completion of the programme, the graduate would have attained the

PO#	Graduate Attribute	Programme Outcome
1.	Engineering Knowledge	Apply knowledge of basic science and engineering science in the design and testing of power electronic systems and drives.
2.	Problem Analysis	Formulate, simulate and design of power electronic converters and drives to meet the performance criteria.
3.	Design / Development of Solutions	Design of power converters and energy efficient drive systems.
4.	Conduct investigations of complex problems	Design the magnetics and controllers, conduct experiments to validate the design on power converters and drives for various industrial applications.
5.	Model tool usage	Model and analyze power electronic systems and drives using computational softwares.
6.	The Engineer and Society	To design power electronic systems and drives to meet the requirements of the societal needs.
7	Environment and Sustainability	To design power electronic systems and electric generators for efficient extraction and utilization of various renewable energy sources.
8.	Ethics	Interact with industry, business andsociety in a professional and ethicalmanner
9.	Individual and team work	Function in a multi-disciplinary team
10.	Communication	Proficiency in oral and writtenCommunication to present technical subjects
11.	Project Management and Finance	Implement cost effective and cutting edge technologies in Power Electronics and Drives system
12.	Life-long learning	Continue professional development andlearning as a life-long activity.

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3.PROGRAMME SPECIFIC OUTCOMES (PSOs):

By the completion of power electronics and drives program the student will have the following programme specific outcomes

1. Foundation of power electronics and drives: Ability to comprehend the need for various power electronics converters and applying the fundamental principles for analysing the different modes of their operation.
2. Adjustable speed electric drives: Ability to analyse, design, simulate and test the various range of drive schemes.
3. Renewable energy extraction and effective utilisation: Ability to understand the power generation from various renewable sources, to analyse the schemes for extracting the maximum power and to know the importance of energy storage systems.
4. Design of controllers: Ability to understand the requirement of modern control technologies applicable to power electronics systems and drives to achieve the desired performance specifications.
5. Design and conduct experiments towards research:Ability to use knowledge in development of new power electronic converters with high power density and efficiency and also in the design and development of high speed drives.

4. PEO / PO Mapping:

Programme Educational Objectives	Programme Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
I	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
II	✓	✓		✓	✓							
III	✓		✓	✓	✓	✓	✓					
IV	✓		✓		✓	✓						
V	✓						✓		✓		✓	
VI								✓		✓	✓	✓

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			PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
YEAR 1	SEM 1	Analysis of Electrical Machines		✓	✓		✓	✓						
		Analysis of Power Converters	✓	✓			✓	✓						
		Modeling and Design of SMPS	✓	✓		✓	✓		✓					
		Program Elective I												
		Research Methodology and IPR												
		Audit course I												
		Power Converters Lab	✓	✓			✓				✓			
		Renewable Energy Lab	✓					✓	✓		✓			
	SEM 2	Analysis of Electrical Drives		✓	✓		✓	✓						
		Special Electrical Machines	✓	✓	✓		✓							
		Vector control of AC Machines	✓	✓	✓		✓							
		Program Elective II												
		Program Elective III												
		Audit course II												
		Power Electronics and Drives Lab			✓	✓	✓				✓	✓		
		Microcontroller and Digital signal processing Lab	✓			✓	✓				✓			
		Mini project with seminar						✓		✓		✓	✓	✓
YEAR 2	SEM 3	Program Elective IV												
		Program Elective V												
		Open Elective												
		Project Phase I	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	SEM 4	Project Phase II	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

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REGULATIONS – 2019
CHOICE BASED CREDIT SYSTEM
M.E. POWER ELECTRONICS AND DRIVES (FULL TIME)
CURRICULUM AND SYLLABUS I TO IV SEMESTERS
SEMESTER I

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	PE5151	Analysis of Electrical Machines	PCC	3	1	0	4	4
2.	PE5152	Analysis of Power Converters	PCC	3	1	0	4	4
3.	PE5153	Modelling and Design of SMPS	PCC	3	0	0	3	3
4.		Program Elective I	PEC	3	0	0	3	3
5.	RM5151	Research Methodology and IPR	RMC	2	0	0	2	2
6.		Audit course I (one from the list of audit courses)	AC	2	0	0	2	0
PRACTICALS								
7.	PE5161	Power Converters Laboratory	PCC	0	0	4	4	2
8.	PW5261	Renewable Energy Laboratory	PCC	0	0	4	4	2
			TOTAL	**16**	**2**	**8**	**26**	**20**

*Audit Course is optional

SEMESTER II

S.NO.	COURSE CODE	COURSETITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	PE5201	Analysis of Electrical Drives	PCC	3	0	0	3	3
2.	PE5251	Special Electrical Machines	PCC	3	0	0	3	3
3.	PE5252	Vector Control of AC Machines	PCC	3	1	0	4	4
4.		Program Elective II	PEC	3	0	0	3	3
5.		Program Elective III	PEC	3	0	0	3	3
6.		Audit course II (one from the list of audit Courses)	AC	2	0	0	2	0
PRACTICALS								
7.	PE5211	Power Electronics and Drives Laboratory	PCC	0	0	4	4	2
8.	PE5212	Microcontroller and Digital Signal Processing Laboratory	PCC	0	0	4	4	2
9.	PE5213	Mini Project with Seminar	EEC	0	0	6	6	3
			TOTAL	**17**	**1**	**14**	**32**	**23**

*Audit Course is optional

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SEMESTER III

S.NO.	COURSE CODE	COURSETITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.		Program Elective IV	PEC	3	0	0	3	3
2.		Program Elective V	PEC	3	0	0	3	3
3.		Open Elective (one from list of 6 courses)	OEC	3	0	0	3	3
PRACTICALS								
4.	PE5311	Project Phase I	EEC	0	0	12	12	6
			TOTAL	**9**	**0**	**12**	**21**	**15**

SEMESTER IV

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	PE5411	Project Phase II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL NO OF CREDITS:70

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CHOICE BASED CREDIT SYSTEM
M.E. POWER ELECTRONICS AND DRIVES (PART TIME)

CURRICULAM AND SYLLABUS I TO VI SEMESTERS

SEMESTER I

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	PE5151	Analysis of Electrical Machines	PCC	3	1	0	4	4
2.	PE5152	Analysis of Power Converters	PCC	3	1	0	4	4
3.		Audit course I (one from the list of audit courses)	AC	2	0	0	2	0
PRACTICALS								
4.	PE5161	Power Converters Laboratory	PCC	0	0	4	4	2
			TOTAL	**8**	**2**	**4**	**14**	**10**

*Audit Course is optional

SEMESTER II

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	PE5201	Analysis of Electrical Drives	PCC	3	0	0	3	3
2.	PE5252	Vector Control of AC Machines	PCC	3	1	0	4	4
3.		Program Elective I	PEC	3	0	0	3	3
4.		Audit course II (one from the list of audit courses)	AC	2	0	0	2	0
PRACTICALS								
5.	PE5211	Power Electronics and Drives Laboratory	PCC	0	0	4	4	2
			TOTAL	**11**	**1**	**4**	**16**	**12**

*Audit Course is optional

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SEMESTER III

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	PE5153	Modelling and Design of SMPS	PCC	3	0	0	3	3
2.		Program Elective II	PEC	3	0	0	3	3
3.	RM5151	Research Methodology and IPR	RMC	2	0	0	2	2
PRACTICALS								
4.	PW5261	Renewable Energy Laboratory	PCC	0	0	4	4	2
			TOTAL	**8**	**0**	**4**	**12**	**10**

SEMESTER IV

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	PE5251	Special Electrical Machines	PCC	3	0	0	3	3
2.		Program Elective III	PEC	3	0	0	3	3
PRACTICALS								
3.	PE5212	Microcontroller and Digital Signal Processing Lab	PCC	0	0	4	4	2
4.	PE5213	Mini Project with Seminar	EEC	0	0	6	6	3
			TOTAL	**6**	**0**	**10**	**16**	**11**

SEMESTER V

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.		Program Elective IV	PEC	3	0	0	3	3
2.		Program Elective V	PEC	3	0	0	3	3
3.		Open Elective (one from the list of 6 courses)	OEC	3	0	0	3	3
PRACTICALS								
4.	PE5311	Project Phase I	EEC	0	0	12	12	6
			TOTAL	**9**	**0**	**12**	**21**	**15**

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SEMESTER VI

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	PE5411	Project Phase II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL NO. OF CREDITS: 70

PROGRAM CORE COURSES (PCC)

SL. NO	COURSE CODE	COURSETITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			L	T	P		
1	PE5151	Analysis of Electrical Machines	3	1	0	4	1
2	PE5152	Analysis of Power Converters	3	1	0	4	1
3	PE5153	Modelling and Design of SMPS	3	0	0	3	1
4	PE5161	Power Converters Laboratory	0	0	4	2	1
5	PW5261	Renewable Energy Laboratory	0	0	4	2	1
6	PE5201	Analysis of Electrical Drives	3	0	0	3	2
7	PE5251	Special Electrical Machines	3	0	0	3	2
8	PE5252	Vector Control of AC Machines	3	1	0	4	2
9	PE5211	Power Electronics and Drives Laboratory	0	0	4	2	2
10	PE5212	Microcontrollers and Digital Signal Processing Laboratory	0	0	4	2	2
		Total Credits				**29**	

PROGRAM ELECTIVE COURSE LIST (PEC)

S.NO	COURSE CODE	COURSE TITLE	L	T	P	CONTACT PERIODS	C
1.	PE5001	Power Semiconductor Devices	3	0	0	3	3
2.	PE5002	Modern Rectifiers and Resonant Converters	3	0	0	3	3
3.	PE5003	Nonlinear Dynamics for Power Electronic Circuits	3	0	0	3	3
4.	PE5004	DSP Based System Design	3	0	0	3	3
5.	PE5005	Control of Power Electronic Circuits	3	0	0	3	3
6.	PE5071	Microcontroller Based System Design	3	0	0	3	3

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7.	PE5072	Advanced Power Converters	3	0	0	3	3
8.	PE5073	Power Electronics for Renewable Energy Systems	3	0	0	3	3
9.	PE5074	Power Quality	3	0	0	3	3
10.	PW5071	Electric Vehicles and Power Management	3	0	0	3	3
11.	PW5074	Energy Storage Technologies	3	0	0	3	3
12.	PW5075	Grid Integration of Renewable Energy Sources	3	0	0	3	3
13.	PW5076	Micro-grid Operation and Control	3	0	0	3	3
14.	PW5077	Renewable Energy Technology	3	0	0	3	3
15.	PS5251	HVDC and FACTS	3	1	0	4	4
16.	PS5075	Smart Grid	3	0	0	3	3
17.	PS5076	Wind Energy Conversion System	3	0	0	3	3
18.	PS5073	Distributed Generation Control and Automation	3	0	0	3	3
19.	PS5074	Optimization Techniques	3	0	0	3	3
20.	CO5152	Intelligent Controllers	3	0	0	3	3
21.	CO5153	MEMS Design: Sensors and Actuators	3	0	0	3	3
22.	CO5151	Control System Design	4	0	0	4	4
23.	CO5075	System Theory	3	0	0	3	3
24.	CO5074	System Identification and Adaptive Control	3	0	0	3	3
25.	HV5151	Electromagnetic Field Computation and Modelling	3	0	0	3	3
26.	ET5071	Advanced Digital Signal Processing	3	0	0	3	3

RESEARCH METHODOLOGY AND IPR COURSES (RMC)

S. NO	COURSE CODE	COURSETITLE	PERIODSPERWEEK			CREDITS	SEMESTER
			L	T	P		
1.	RM5151	Research Methodology and IPR	2	0	0	2	1
					Total Credits:	**2**	

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OPEN ELECTIVE COURSES [OEC]

*(Out of 6 Courses one Course must be selected)

S.NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	OE5091	Business Data Analytics	3	0	0	3	3
2.	OE5092	Industrial Safety	3	0	0	3	3
3.	OE5093	Operations Research	3	0	0	3	3
4.	OE5094	Cost Management of Engineering Projects	3	0	0	3	3
5.	OE5095	Composite Materials	3	0	0	3	3
6.	OE5096	Waste to Energy	3	0	0	3	3

AUDIT COURSES (AC)

Registration for any of these courses is optional to students

SL. NO	COURSE CODE	COURSETITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lectur	Tutorial	Practical		
1.	AX5091	English for Research Paper Writing	2	0	0	0	1/2
2.	AX5092	Disaster Management	2	0	0	0	
3.	AX5093	Sanskrit for Technical Knowledge	2	0	0	0	
4.	AX5094	Value Education	2	0	0	0	
5.	AX5095	Constitution of India	2	0	0	0	
6.	AX5096	Pedagogy Studies	2	0	0	0	
7.	AX5097	Stress Management by Yoga	2	0	0	0	
8.	AX5098	Personality Development Through Life Enlightenment Skills	2	0	0	0	
9.	AX5099	Unnat Bharat Abhiyan	2	0	0	0	
Total Credits						**0**	

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. NO	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1.	PE5213	Mini Project Technical Seminar	EEC	2	0	0	2	1
2.	PE5311	Project Phase I	EEC	12	0	0	12	6
3.	PE5411	Project Phase II	EEC	24	0	0	24	12

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SUMMARY

M.E POWER ELECTRONICS AND DRIVES							
SL. NO.	SUBJECT AREA	CREDITS PER SEMESTER				TOTAL CREDITS	%
		I	II	III	IV		
1.	PCC	15	14	0	0	**29**	**41**
2.	PEC	3	6	6	0	**15**	**22**
3.	RMC	2	0	0	0	**2**	**3**
4.	OEC	0	0	3	0	**3**	**4**
5.	EEC	0	3	6	12	**21**	**30**
6.	Non Credit / Audit Course	✓	✓	0	0	**0**	**0**
	Total Credits	**20**	**23**	**15**	**12**	**70**	

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PE5151	ANALYSIS OF ELECTRICAL MACHINES	L	T	P	C
		3	1	0	4

COURSE OBJECTIVES:

- To provide knowledge about the fundamentals of magnetic circuits, energy, force and torque of multi-excited systems.
- To analyze the steady state and dynamic state operation of DC machine through mathematical modeling and simulation in digital computer.
- To provide the knowledge of theory of transformation of three phase variables to two phase variables.
- To analyze the steady state and dynamic state operation of three-phase induction machines using transformation theory based mathematical modeling and digital computer simulation.
- 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 I PRINCIPLES OF ELECTRO MAGNETIC ENERGY CONVERSION 12

Magnetic circuits, permanent magnet, stored magnetic energy, co-energy - force and torque in singly and doubly excited systems – machine windings and air gap mmf– determination of winding resistances and inductances of machine windings – determination of friction coefficient and moment of inertia of electrical machines.

UNIT II DC MACHINES 12

Elementary DC machine and analysis of steady state operation - Voltage and torque equations – dynamic characteristics of permanent magnet and shunt DC motors – electrical and mechanical time constants - Time domain block diagrams –transfer function of DC motor-responses – digital computer simulation of permanent magnet and shunt DC machines.

UNIT III REFERENCE FRAME THEORY 12

Historical background of Clarke and Park transformations – power invariance and phase transformation and commutator transformation – transformation of variables from stationary to arbitrary reference frame - variables observed from several frames of reference.

UNIT IV INDUCTION MACHINES 12

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 – modeling of multiphase machines - digital computer simulation of three phase induction machines.

UNIT V SYNCHRONOUS MACHINES 12

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 – digital computer simulation of synchronous machines.

TOTAL : 60 PERIODS

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COURSE OUTCOMES:

CO1 Ability to optimally design magnetics required in power supplies and drive systems.
CO2 Ability to acquire and apply knowledge of mathematics of machine dynamics in Electrical engineering.
CO3 Ability to model, simulate and analyze the dynamic performance of electrical machines using computational software.
CO4 Ability to formulate, design, simulate power supplies and loads for complete electrical machine performance
CO5 Ability to verify the results of the dynamic operation of electrical machine systems

CO	PO											
	1	2	3	4	5	6	7	8	9	10	11	12
1	✓	✓	✓	✓	✓							
2	✓	✓	✓	✓	✓				✓	✓		
3	✓	✓	✓	✓	✓				✓	✓		
4	✓	✓	✓	✓	✓				✓	✓		
5	✓	✓	✓	✓	✓				✓	✓		

TEXT BOOKS:

1. PaulC.Krause, Oleg Wasyzczuk, Scott S, Sudhoff, "Analysis of Electric Machinery and Drive Systems", John Wiley, Second Edition, 2010.
2. R Ramanujam,"Modelling and Analysis of Electrical Machines", I.K International Publishing Pvt. Ltd., New Delhi, 2018

REFERENCES:

1. P S Bimbhra, "Generalized Theory of Electrical Machines", Khanna Publishers, 2008.
2. A.E, Fitzgerald, Charles Kingsley, Jr, and Stephan D, Umanx, " Electric Machinery", Tata McGraw Hill, 5th Edition,199

PE5152 ANALYSIS OF POWER CONVERTERS

L	T	P	C
3	1	0	4

COURSE OBJECTIVES:

- To provide the mathematical fundamentals necessary for deep understanding of power converter operating modes.
- To provide the electrical circuit concepts behind the different working modes of power converters so as to enable deep understanding of their operation.
- To provide required skills to formulate and design inverters for generic load and for machine loads.
- To equip with required skills to derive the criteria for the design of power converters starting from basic fundamentals.
- To analyze and comprehend the various operating modes of different configurations of power converters

UNIT I SINGLE PHASE AC-DC CONVERTER 12

Static Characteristics of power diode, SCR and GTO, half controlled and fully controlled converters with R-L, R-L-E loads and freewheeling diodes – continuous and discontinuous modes of operation - inverter operation –Sequence control of converters – performance parameters:

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harmonics, ripple, distortion, power factor – effect of source impedance and overlap-reactive power and power balance in converter circuits

UNIT II THREE PHASE AC-DC CONVERTER 12

Semi and fully controlled converter with R, R-L, R-L-E - loads and freewheeling diodes – inverter operation and its limit – performance parameters – effect of source impedance and overlap-12 pulse converter

UNIT III SINGLE PHASE INVERTERS 12

Introduction to self-commutated switches : MOSFET and IGBT - Principle of operation of half and full bridge inverters – Performance parameters – Voltage control of single phase inverters using various PWM techniques – various harmonic elimination techniques – Design of UPS-VSR operation

UNIT IV THREE PHASE INVERTERS 12

180 degree and 120 degree conduction mode inverters with star and delta connected loads – voltage control of three phase inverters: single, multi pulse, sinusoidal, space vector modulation techniques – VSR operation-Application to drive system – Current source inverters.

UNIT V MODERN INVERTERS 12

Multilevel concept – 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.

TOTAL : 60 PERIODS

COURSE OUTCOMES:

CO1 Ability to acquire and apply knowledge of mathematics in power converter analysis
CO2 Ability to model, analyze and understand power electronic systems and equipment
CO3 Ability to formulate, design and simulate phase controlled rectifiers for generic load and for machine loads
CO4 Ability to formulate, design, simulate switched mode inverters for generic load and for machine loads
CO5 Ability for device selection and calculation of performance parameters of power converters under various operating modes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓									✓
CO2	✓	✓	✓		✓							✓
CO3	✓	✓	✓		✓	✓	✓				✓	
CO4	✓	✓	✓		✓	✓	✓				✓	
CO5	✓	✓	✓		✓	✓					✓	✓

TEXT BOOKS:

1. Rashid M.H., “Power Electronics Circuits, Devices and Applications ", Prentice Hall India, fourth Edition, New Delhi, 2014.
2. Jai P. Agrawal, “Power Electronics Systems”, Pearson Education, Second Edition, 2002.
3. Bimal.K.Bose “Modern Power Electronics and AC Drives”, Pearson Education, Second Edition, 2003.
4. Ned Mohan, T.M.Undeland and W.P.Robbins, “Power Electronics: converters, Application and design” John Wiley and sons. Wiley India edition, 2006.
5. Philip T. krein, “Elements of Power Electronics” Oxford University Press-1998.

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REFERENCES:

1. P.C.Sen, “Modern Power Electronics”, Wheeler Publishing Co,First Edition, New Delhi, 1998.
2. P.S.Bimbhra, “Power Electronics”, Khanna Publishers, Eleventh Edition, 2003.
3. Bin Wu, Mehdi Narimani, "High-power Converters and AC Drives", Wiley, 2nd Edition, 2017.

PE5153	MODELLING AND DESIGN OF SMPS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To perform steady state analysis of **Non-Isolated DC-DC** DC-DC converter.
- To perform steady state analysis of **Isolated** DC-DC converter.
- To understand different converter dynamics.
- To design controllers for DC DC converters.
- To design magnetics for SMPS applications.

UNIT I ANALYSIS OF NON-ISOLATED DC-DC CONVERTERS 9

Buck, Boost, Buck- Boost and Cuk converters: Principles of operation – Continuous conduction mode– Concepts of volt-sec balance and charge balance – Analysis and design based on steady-state relationships – Introduction to discontinuous conduction mode other topologies, SEPIC topologies - design examples.

UNIT II ANALYSIS OF ISOLATED DC-DC CONVERTERS 9

Introduction - classification- forward- flyback- pushpull- halfbridge- fullbridge topologies- design of SMPS

UNIT III CONVERTER DYNAMICS 9

AC equivalent circuit analysis – State space averaging – Circuit averaging – Averaged switch modeling – Transfer function model for buck, boost, buck-boost and cuk converters – Input filters.

UNIT IV CONTROLLER DESIGN 9

Review of P, PI, and PID control concepts – gain margin and phase margin – Bode plot based analysis – Design of controller for buck, boost, buck-boost and cuk converters.

UNIT V DESIGN OF MAGNETICS 9

Basic magnetic theory revision – Inductor design – Design of mutual inductance – Design of transformer for isolated topologies – Ferrite core table and selection of area product – wire table – selection of wire gauge.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

CO1 Ability to design **Non-Isolated DC-DC**.
CO2 Ability to design **Isolated** DC-DC converter.
CO3 Ability to derive transfer function of different converters.
CO4 Ability to design controllers for DC DC converters.
CO5 Ability to design magnetics for SMPS applications

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓			✓		✓					
CO2	✓	✓			✓		✓					
CO3	✓	✓										
CO4	✓	✓		✓	✓		✓					
CO5	✓	✓		✓								

TEXT BOOKS:

1. Robert W. Erickson & Dragon Maksimovic, " Fundamentals of Power Electronics", Second Edition, 2001 Springer science and Business media

REFERENCES:

1. John G. Kassakian, Martin F. Schlecht, George C. Verghese, "Principles of Power Electronics", Pearson, India, New Delhi, 2010.
2. Simon Ang and Alejandra Oliva, "Power-Switching Converters", CRC press, 3rd edition, 2011.
3. Philip T Krein, " Elements of Power Electronics", Oxford University Press, 2017.
4. Ned Mohan, "Power Electronics: A first course", John Wiley,2012.
5. Issa Batarseh, Ahmad Harb, "Power Electronics- Circuit Analysis and Design, Second edition.

RM5151 RESEARCH METHODOLOGY AND IPR LT P C
2 0 0 2

COURSE OBJECTIVES:

To impart knowledge and skills required for research and IPR:

- Problem formulation, analysis and solutions.
- Technical paper writing / presentation without violating professional ethics
- Patent drafting and filing patents.

UNIT I RESEARCH PROBLEM FORMULATION 6

Meaning of research problem- Sources of research problem, criteria characteristics of a good research problem, errors in selecting a research problem, scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, necessary instrumentations

UNIT II LITERATURE REVIEW 6

Effective literature studies approaches, analysis, plagiarism, and research ethics.

UNIT III TECHNICALWRITING /PRESENTATION 6

Effective technical writing, how to write report, paper, developing a research proposal, format of research proposal, a presentation and assessment by a review committee.

UNIT IV INTRODUCTION TO INTELLECTUAL PROPERTY RIGHTS (IPR) 6

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

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UNIT V INTELLECTUAL PROPERTY RIGHTS (IPR) 6

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System, IPR of Biological Systems, Computer Software etc.

Traditional knowledge Case Studies, IPR and IITs.

TOTAL: 30 PERIODS

COURCE OUTCOMES:

1. Ability to formulate research problem
2. Ability to carry out research analysis
3. Ability to follow research ethics
4. Ability to understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity
5. Ability to understand about IPR and filing patents in R & D.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓										
CO2	✓											
CO3	✓							✓				
CO4	✓				✓							
CO5	✓					✓						✓

REFERENCES:

1. Asimov, "Introduction to Design", Prentice Hall, 1962.
2. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
3. Mayall, "Industrial Design", McGraw Hill, 1992.
4. Niebel, "Product Design", McGraw Hill, 1974.
5. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners" 2010

PE5161	POWER CONVERTERS LABORATORY	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

- To provide the requisite knowledge necessary to appreciate the dynamical equations involved in the analysis of different PED configurations.
- To understand the dynamics and different operating modes of power converters studied in the core courses on power converters.
- To analyze, design and simulate different rectifier circuits for generic load and for machine loads
- To simulate different inverter topologies.
- To formulate, design, simulate power supplies for generic load and for machine loads.

LIST OF EXPERIMENTS:

1. Simulation of single phase half wave controlled converter fed RLE load.
2. Simulation of single phase fully controlled converter fed RLE load.
3. Simulation of three phase half controlled converter fed RL load.
4. Simulation of three phase fully controlled converter fed RL load.

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5. Study of single phase Fully Controlled Rectifier, Half Controlled Rectifier with different Loads.
6. Study of Three phase Fully Controlled Rectifier, Half Controlled Rectifier with different Loads.
7. Simulation of single phase VSI fed RL/RC load.
8. Design of UPS.
9. Design of SMPS.
10. Simulation of multilevel inverter topologies.

TOTAL : 60 PERIODS

COURSE OUTCOMES:

CO1:Ability to solve dynamic equations involved in power electronics.

CO2:Ability to acquire and apply knowledge of mathematics and converter/machine dynamics in Electrical engineering.

CO3:Ability to model and analyze different rectifier circuits using computational software and to understand their various operating modes.

CO4:Ability to model and analyze different rectifier circuits using computational software and to understand their various operating modes.

CO5:Ability to formulate, design, simulate power supplies for generic load and for machine loads.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓			✓				✓			
CO2	✓	✓			✓				✓			
CO3	✓	✓			✓				✓			
CO4	✓	✓			✓				✓			
CO5	✓	✓			✓				✓			

REFERENCES:

1. Ned Mohan, T.M.Undeland 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 Hal India, New Delhi, 1995.

PW5261 **RENEWABLE ENERGY LABORATORY** **LT P C**
0 0 4 2

COURSE OBJECTIVES

Students will be able to:

- Study the performance of various renewable energy sources.
- Obtain hands-on experience on various wind turbine operation.
- Analyze the grid integration issues of renewable energy sources.
- To analyze the performance characteristics of DFIG and PMSG.
- To design and model PV system integration with grid.

1. Performance characteristics of solar PV panel.
2. Performance of PV panel in series and parallel combination.
3. VI characteristics of fuel cell.
4. Performance characteristics of self- excited Induction Generator.
5. Performance characteristics of DFIG.
6. Performance characteristics of PMSG.

7. MPPT tracking of DFIG based WT.
8. MPPT tracking of PMSG based WT.
9. Grid integration of RES.

TOTAL 60 PERIODS

COURSE OUTCOMES

CO1: Students will understand the characteristics of various renewable energy sources.

CO2: Students will be able to program different MPPT algorithm and understand their merits and demerits

CO3: Students will learn control of DFIG .

CO4: Students will learn control of PMSG .

CO5: Students will design and model PV system integration with grid.

MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓				✓	✓	✓	✓	✓	✓	✓	
CO2	✓				✓	✓	✓	✓	✓	✓	✓	
CO3	✓				✓	✓	✓	✓	✓	✓	✓	
CO4	✓				✓	✓	✓	✓	✓	✓	✓	
CO5	✓				✓	✓	✓	✓	✓	✓	✓	✓

PE5201 ANALYSIS OF ELECTRICAL DRIVES

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

To understand steady state operation and transient dynamics of a motor load system

- To study and analyze the operation of the converter / chopper fed DC drive, both qualitatively and quantitatively
- To analyze and design the current and speed controllers for a closed loop solid state DC motor drive.
- To understand the drive characteristics for different load torque profiles and quadrants of operation
- To understand the speed control of induction motor drive from stator and rotor sides.
- To study and analyze the operation of VSI &CSI fed induction motor control and pulse width modulation techniques

UNIT I DC MOTORS FUNDAMENTALS AND MECHANICAL SYSTEMS 9

DC motor- Types, induced emf, speed-torque relations; Speed control – Armature and field speed control; Ward Leonard control – Constant torque and constant horse power 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.

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UNIT II CONVERTER AND CHOPPER CONTROL 9

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 III CLOSED LOOP CONTROL 9

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 IV VSI AND CSI FED STATOR CONTROLLED INDUCTION MOTOR CONTROL 9

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 V ROTOR CONTROLLED INDUCTION MOTOR DRIVES 9

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: 45 PERIODS

COURSE OUTCOMES:

CO1Ability to acquire and apply knowledge of mathematics and converter/machine dynamics in Electrical engineering.
CO2 Ability to formulate, design, simulate power supplies for generic load and for machine loads.
CO3 Ability to analyze, comprehend, design and simulate direct current motor based adjustable speed drives.
CO4 Ability to analyze, comprehend, design and simulate induction motor based adjustable speed drives.
CO5Ability to design a closed loop motor drive system with controllers for the current and speed control operations.

CO	PO											
	1	2	3	4	5	6	7	8	9	10	11	12
1	✓	✓	✓	✓	✓							
2	✓	✓	✓	✓	✓				✓	✓		
3	✓	✓	✓	✓	✓				✓	✓		
4	✓	✓	✓	✓	✓				✓	✓		
5	✓	✓	✓	✓	✓				✓	✓		

TEXT BOOKS:

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. Bimal K Bose, “Modern Power Electronics and AC Drives”, Pearson Education Asia2002.

REFERENCES:

1. Gopal K.Dubey, “Fundamentals of Electrical Drives”, Narosal Publishing House, New Delhi, Second Edition, 2009
2. Vedam Subramanyam, “Electric Drives – Concepts and Applications”, Tata McGraw-Hill publishing company Ltd., New Delhi, 2002.
3. P.C Sen “Thyristor DC Drives”, John wiely and sons, New York, 1981.
4. W.Leonhard, “Control of Electrical Drives”, Narosa Publishing House, 1992
5. Murphy J.M.D and Turnbull, “Thyristor Control of AC Motors”, Pergamon Press, Oxford, 1988

PE5251 SPECIAL ELECTRICAL MACHINES L T P C
3 0 0 3

COURSE OBJECTIVES:

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

UNIT I 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 II PERMANENT MAGNET SYNCHRONOUS 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 III 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 IV STEPPER MOTORS 9

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

UNIT V OTHER SPECIAL MACHINES 9

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

TOTAL : 45 PERIODS

COURSE OUTCOMES:

CO1 Ability to model and analyze power electronic systems and equipment using computational software.

CO2 Ability to optimally design magnetics required in special machines based drive systems using FEM based software tools.

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CO3 Ability to analyse the dynamic performance of special electrical machines
CO4 Ability to understand the operation and characteristics of other special electrical machines.
CO5 Ability to design and conduct experiments towards research.

TEXT BOOKS:

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.

REFERENCES:

1. T.Kenjo and S.Nagamori, 'Permanent magnet and Brushless DC motors', Clarendon press, London,1988.
2. R.Krishnan, 'Electric motor drives', Prentice hall of India,2002.
3. D.P.Kothari and I.J.Nagrath, ' Electric machines', Tata McGraw hill publishing company, New Delhi, Third Edition,2004.
4. Irving L.Kosow, "Electric Machinery and Transformers" Pearson Education, Second Edition,2007.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓					✓				
CO2	✓	✓	✓	✓				✓				
CO3	✓	✓	✓	✓				✓				
CO4	✓	✓	✓	✓				✓				
CO5	✓	✓										

PE5252 VECTOR CONTROL OF AC MACHINES

L	T	P	C
3	1	0	4

COURSE OBJECTIVES:

- To study the space phasor model of alternating current machines.
- To understand the field oriented control for permanent magnet synchronous machines.
- To analyse the concept of vector control based salient pole machines.
- To provide the knowledge about concept and control techniques of induction motor.
- To develop the flux oriented control circuit for induction motor.

UNIT I SPACE PHASOR MODEL OF AC MACHINES 12

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

UNIT II VECTOR CONTROL OF PM SYNCHRONOUS MACHINE 12

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

UNIT III VECTOR CONTROL OF SALIENT POLE MACHINE WITH ELECTRICALLY EXCITED ROTOR 12

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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 IV STATOR FLUX ORIENTED CONTROL OF INDUCTION MACHINE 12

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

UNIT V ROTOR FLUX ORIENTED CONTROL OF INDUCTION MACHINE 12

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 : 60 PERIODS

COURSE OUTCOMES:

CO1: Ability to carry out space phasor model for electrical machines.
CO2: Able to synthesis the vector controller for permanent magnet synchronous machines.
CO3: Able to compute and analyse the controllers of salient pole machines.
CO4: Able to understand and select the various control schemes suitable for induction motor.
CO5: The students acquire the flux oriented control concept of induction motor.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓		✓								✓	
CO2	✓	✓	✓	✓								
CO3	✓		✓									
CO4	✓	✓		✓								
CO5	✓		✓									

TEXT BOOKS:

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.

REFERENCES:

1. Peter Vas, “Sensorless Vector and Torque Control”, Oxford University press, 1998.
2. PaulC.Krause, Oleg Wasyzczuk, Scott S, Sudhoff, “Analysis of Electric Machinery and Drive Systems”, John Wiley, Second Edition, 2010.

PE5211 POWER ELECTRONICS AND DRIVES LABORATORY L T P C
0 0 4 2

COURSE OBJECTIVES:

- To design and simulate power supplies for generic load and for machine loads
- To design magnetics used in power supplies and drive systems
- To conduct load tests in drive system
- To conduct experiments and enhance understanding of different power electronic controller for power supplies and motor drive applications.

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- To generate PWM rating signals and to study drive circuits used in Power electronic converters.

LIST OF EXPERIMENTS:

1. Speed control of Converter fed DC motor.
2. Speed control of Chopper fed DC motor.
3. V/f control of three-phase induction motor.
4. Micro controller based speed control of Stepper motor.
5. Speed control of BLDC motor.
6. DSP based speed control of SRM motor.
7. Simulation of Four quadrant operation of three-phase induction motor.
8. Voltage Regulation of three-phase Synchronous Generator.
9. AC voltage Controller based speed control of induction motor.
10. Study of driver circuits and generation of PWM signals for three phase inverters.

TOTAL : 60 PERIODS

COURSE OUTCOMES:

CO1 Ability to formulate, design, simulate power supplies for generic load and for machine loads.
CO2 Ability to optimally design magnetics required in power supplies and drive systems.
CO3 Ability to conduct harmonic analysis and load tests on power supplies and drive systems.
CO4 Ability to design and conduct experiments towards research.
CO5 Ability to understand the various power electronic controllers used in drive systems.

REFERENCES:

1. Ned Mohan, T.M. Undeland 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 Hal India, New Delhi, 1995.

	O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	O11	O12
O1	✓	✓		✓					✓			✓
O2	✓	✓		✓		✓			✓			✓
O3	✓	✓		✓		✓			✓			✓
O4	✓	✓		✓					✓			✓
O5	✓	✓		✓					✓			✓

PE5212	MICROCONTROLLER AND DIGITAL SIGNAL PROCESSING LABORATORY	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

- To perform simple arithmetic operations using assembly language program and study the addressing modes & instruction set of **µ**C 8051/ PIC **µ**C /DSP
- To develop skills in simple program writing in assembly languages
- To write an assembly language program to convert Analog input to Digital output and Digital input to Analog output.
- To perform interfacing experiments with **µ**C8051/ PIC **µ**C /DSP

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LIST OF EXPERIMENTS:

Programming with 8-bit micro-controller µC8051 using trainer kit/ In-Circuit Prog board/ Assembler package/ IDE:

1. Simple arithmetic operations: Multi precision addition / subtraction, using binary/ BCD, signed / unsigned, multiplication /division.
2. Interface Experiments: Sensor interfacing (analog and digital) Stepper motor controller interface.
3. Programming exercises using built-in timers using assembly/ embedded C language.
4. Programming exercises on serial communication using assembly/ embedded C language

Programming with 8-bit micro-controller PICµC using trainer kit/ In Circuit Prog board/ Assembler package/ IDE:

5. Simple arithmetic operations: Multi precision addition / subtraction, using binary/ BCD, signed / unsigned, multiplication /division.
6. Interface Experiments: Sensor interfacing (analog and digital) Stepper motor controller interface.
7. Programming exercises using built-in timers using assembly/ embedded C language.
8. Programming exercises on serial communication using assembly/ embedded C language.

Experiments with Fixed Point Digital Signal Processor kits:

9. Simple arithmetic operations: Multi precision addition / subtraction, using binary/ BCD, signed / unsigned, sorting of numbers, multiplication /division.
10. Interface Experiments: Sensor interfacing (analog and digital)
Stepper motor controller interface.
11. Programming exercises using built-in timers using assembly language & generation of chopper control signals.
12. Generation of firing pulses for control of a 3-phase VSI using Sinusoidal PWM or Space Vector PWM.
13. Digital implementation of P, PI controllers with limiters.

TOTAL : 60 PERIODS

COURSE OUTCOMES:

CO1 Ability to perform simple arithmetic operations using the assembly language of µc8051 employing different addressing modes

CO2 Ability to perform simple arithmetic operations using the assembly language of PICµC employing different addressing modes

CO3 Ability to perform simple arithmetic operations using the assembly language of Digital signal processor employing different addressing modes

CO4 Ability to write assembly language program to convert Analog input to Digital output and digital input to analog output using µc8051/PICµc/DSP

CO5 Ability to perform interfacing experiments with µc8051/PICµc/DSP

	O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	O11	O12
O1	✓				✓				✓		✓	
O2	✓				✓				✓		✓	
O3		✓			✓				✓		✓	
O4	✓	✓			✓				✓		✓	✓
O5	✓		✓			✓			✓		✓	

Attested

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TEXT BOOKS:

1. Muhammad Ali Mazidi & Janice GilliMazidi, " PIC programming"
2. Muhammad Ali Mazidi & Janice GilliMazidi, 'The 8051 Micro Controller and Embedded Systems', Pearson Education, 2007.
3. Kenneth Ayala, 'The 8051Microcontroller', Thomson, 2005.

REFERENCES:

1. Hamid A Toliyat and Steven Campbell, " DSP based Electromechanical motion Control" , CRC press ,2004

PE5001	POWER SEMICONDUCTOR DEVICES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To select proper power semiconductor device for power electronic circuit applications.
- To understand the static and dynamic characteristics of current controlled power semiconductor devices.
- To understand the static and dynamic characteristics of voltage controlled power
- To understand the protection and firing circuit for different devices.
- To know about the wide band gap power switching devices.

UNIT I INTRODUCTION 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 - Power diodes - Types, forward and characteristics, switching characteristics – rating.

UNIT II CURRENT CONTROLLED DEVICES 9

BJT's – Construction, static characteristics, switching characteristics; Power darlington- Thyristors – Physical and electrical principle underlying operating mode, Two transistor analogy – 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-driving circuit for BJT and Thyristor.

UNIT III 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 – driving circuits-Basics of GTO, MCT, FCT, RCT and IGCT.

UNIT IV DEVICE PROTECTION 9

Necessity of isolation - Over voltage, over current and gate protections; Design of snubbers. Heat transfer – conduction, convection and radiation; Cooling – liquid cooling, vapour – phase cooling; Guidance for hear sink selection – Electrical analogy of thermal components, heat sink types and design – Mounting types.

UNIT V 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.

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TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1 Ability to select the switching device suitable for given power electronic converter.
CO2 To be able to understand the principle of voltage controlled devices.
CO3 To be able to understand the principle of current controlled devices.
CO4 Ability to understand the control protection and firing circuits required for different switching devices
CO5 Ability to know about wide band gap devices.

TEXTBOOKS:

1. B.W Williams 'Power Electronics Circuit Devices and Applications'.
2.Rashid M.H., "Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Third Edition, New Delhi, 2004.
3.B. JayantBaliga, Silicon Carbide Power Devices, World Scientific,2005
4. Josef Lutz, Heinrich Schlangenotto, UweScheuermann, Rik De Doncker, Semiconductor Power Devices Physics, Characteristics, Reliability, Second Edition,Springer,2018

REFERENCES:

1. Robert Perret, Power Electronics Semiconductor Devices, ISTE Ltd,2009
2. Mohan, Undeland and Robins, "Power Electronics – Concepts, applications and Design, John Wiley and Sons, Singapore, 2000.
3. AlexLidow, Johan Strydom, Michael de Rooij, David Reusch, GaNTransistors for Efficient Power Conversion, Second Edition, Wiley, 2015.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	✓						✓	
CO2	✓	✓	✓	✓	✓							
CO3	✓	✓	✓	✓	✓							
CO4	✓	✓	✓	✓	✓							
CO5	✓	✓	✓	✓	✓							

PE5002	MODERN RECTIFIERS AND RESONANT CONVERTERS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the harmonics standards
- To analyse and design power factor correction rectifiers for UPS applications.
- To analyse and design resonant converters for SMPS applications.
- To carry out of dynamic analysis of DC to DC Converters**.**
- To introduce the control techniques for control of resonant converters.

UNIT I POWER SYSTEM HARMONICS & LINE COMMUTATED RECTIFIERS 9

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

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UNIT II PULSE WIDTH MODULATED RECTIFIERS 9

Properties of Ideal rectifiers-Realization of non-ideal rectifier-Control of current waveform- Average current control-Current programmed Control- Hysteresis control- Nonlinear carrier control-Single phase converter system incorporating ideal rectifiers-Modeling losses and efficiency in CCM high quality rectifiers-Boost rectifier-expression for controller duty cycle-expression for DC load current-solution for converter Efficiency η.

UNIT III RESONANT CONVERTERS 9

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

UNIT IV DYNAMIC ANALYSIS OF SWITCHING CONVERTERS 9

Review of linear system analysis-State Space Averaging-Basic State Space Average Model- State Space Averaged model for Buck Converter, Boost Converter, Buck Boost Converter and Cuk Converter.

UNIT V CONTROL OF RESONANT CONVERTERS 9

Pulse Width Modulation-Voltage Mode PWM Scheme-Current Mode PWM Scheme-Design of Controllers: PI Controller, Variable Structure Controller, Optimal Controller for the source current shaping of PWM rectifiers.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

CO1Ability to acquire and apply knowledge of mathematics in power converter analysis and understanding of harmonic standards
CO2 Ability to analyze and understand power electronic systems and equipment
CO3. Ability to analyze, design and simulate resonant converters for low power applications
CO4.Ability to develop mathematical model of switching converters to carry out dynamic analysis
CO5.Ability to design and implement different controllers and switching schemes for the control of converters

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓			✓	✓					✓
CO2	✓	✓	✓			✓						✓
CO3	✓	✓	✓				✓				✓	
CO4	✓	✓	✓	✓	✓							
CO5	✓	✓	✓	✓	✓						✓	✓

TEXTBOOKS:

1. Robert W. Erickson &Dragon Maksimovic “Fundamentals of Power Electronics” Second Edition, 2001 Springer science and Business media
2. William Shepherd and Li zhang ”Power Converters Circuits”MarceldEkkerin, C.
3. Simon Ang and Alejandro Oliva “Power- Switching Converters” Taylor &FrancisGroup

REFERENCE:

1. John G. Kassakian, Martin F. Schlecht, George C. Verghese, “Principles of Power Electronics”, Pearson, India, New Delhi, 2010.
2. Simon Ang and Alejandra Oliva, “Power Switching Converter”, Yesdee publishers, New Delhi, 2nd edition (first Indian Reprint), 2010.

3. Philip T Krein, " Elements of Power Electronics", Oxford University Press
4. Ned Mohan, "Power Electronics: A first course", John Wiley,2012
5. IssaBatarseh, Ahmad Harb, "Power Electronics- Circuit Analysis and Design, Second edition.

PE5003	NONLINEAR DYNAMICS FOR POWER ELECTRONIC CIRCUITS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the non linear behavior of power electronic converters.
- To understand the techniques for investigation on non linear behavior of power electronic converters.
- To analyse the nonlinear phenomena in DC to DC converters.
- To analyse the nonlinear phenomena in AC and DC Drives.
- To introduce the control techniques for control of non linear behavior in power electronic systems.

UNIT I BASICS OF NONLINEAR DYNAMICS 9

Basics of Nonlinear Dynamics: System, state and state space model, Vector field- Modeling of Linear, nonlinear and Linearized 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 II TECHNIQUES 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 III 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 IV NONLINEAR PHENOMENA IN DRIVES 9

Nonlinear Phenomenon in Current controlled and voltage controlled DC Drives, Nonlinear Phenomenon in PMSM Drives.

UNIT V 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:

CO1Ability to understand, model and simulate chaotic behavior in power electronic systems.
CO2 Ability to investigate the various techniques of non linear phenomena
CO3 Ability to analyze the nonlinear phenomena in DC-DC converter

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CO4 Ability to analyze the non linear phenomena in Drives
CO5 Ability to mitigate chaotic behavior noticed in power system.

TEXT BOOKS:

1. George C. Vargheese, July 2001 Wiley – IEEE Press S Banerjee, Nonlinear Phenomenon Power Electronics, IEEE Press
2. Steven H Strogatz, Nonlinear Dynamics and Chaos, Westview Press

REFERENCES:

1. C.K.TSE Complex Behaviour of Switching Power Converters, CRC Press,2003
2. Alfredo Medio, Marji Lines, "Non Linear Dynamics: A primer", Cambridge University Press, 2003.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓				✓						
CO2	✓	✓				✓						
CO3	✓	✓	✓	✓								
CO4	✓	✓	✓	✓								
CO5	✓	✓	✓	✓								

PE5004 DSP BASED SYSTEM DESIGN

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To provide the requisite knowledge for the designing of control/triggering/closed loop circuitry employing embedded controller readily available.
- To provide with the requisite knowledge for the interfacing of the digital controllers with power electronics system for better control.
- To understand the architecture, programming methods and their special features as relevant to PE Drives
- To understand design of DSP controlled systems especially for the PE interface.
- To provide knowledge about the digital implementation of conventional controllers.

UNIT I MOTOR CONTROL SIGNAL PROCESSORS 9

Introduction- Core architecture of 2000 family of Digital Signal Processors- System configuration registers - Memory mapping in microcontroller mode.

UNIT II ASSEMBLY LANGUAGE PROGRAMMING 9

Instruction set – Addressing modes-Programming techniques – simple programs: Arithmetic and interfacing examples, program using MAC, SQRA instruction, use of Look-Up Tables.

UNIT III PERIPHERALS OF SIGNAL PROCESSORS 9

General purpose Input/Output (GPIO) Functionality- Interrupts –Built in analog to digital converter and its sequence control.

UNIT IV EVENT MANAGER AND DRIVE CONTROL 9

Event Managers (EVA, EVB), Timers, full compare units, capture units- PWM signal

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generation-SVPWM features

UNIT V APPLICATIONS OF SIGNAL PROCESSORS 9

Voltage regulation of DC-DC converters- Stepper motor and DC motor control- Clarke's and parks transformation-Space vector PWM-Implementation of digital P, PI and PID controllers.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1 Ability to understand the features in the core architecture of 2000 family DS Processors
CO2 Ability to write simple assembly language program using Digital signal processor instruction set
CO3 Ability to understand features relevant to power electronic drives in the DS Processors
CO4 Ability to write program for PWM signal generation using event manager of DS processors.
CO5 Ability to develop programs for the embedded control of electrical drives.

TEXT BOOKS:

1. Hamid A.Toliyat, Steven Campbell, 'DSP based electromechanical motion control', CRC Press, 2004.

REFERENCES:

1. SenM.Kuo, Bob H.Lee and WenshunTian, "Real-Time Digital Signal Processing: Implementations and Applications", Second Edition.
2. Avtar Singh, S. Srinivasan, "Digital Signal Processing Implementation", Thomson Press, 2004.

	O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	O11	O12
O1	✓								✓		✓	
O2		✓			✓	✓			✓			✓
O3		✓	✓		✓	✓	✓					
O4		✓	✓			✓	✓		✓			
O5		✓	✓				✓				✓	

PE5005 CONTROL OF POWER ELECTRONIC CIRCUITS L T P C
3 0 0 3

COURSE OBJECTIVES:

- To study the basics of control for power electronic circuits.
- To understand the principles behind flatness based control and sliding mode control.
- To know about the controller design for power converter circuits.
- To understand the principles behind sliding mode control
- To gain the knowledge related with flatness based controller design

UNIT I CONTROLLER DESIGN FOR BASIC DC-DC CONVERTERS- PART I 9

Introduction , Review of Linear Control Theory, Linearization of Various Transfer Function Blocks, Feedback Controller Design in Voltage-Mode Control, Peak-Current Mode Control, Feedback Controller Design in DCM

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UNIT II CONTROLLER DESIGN FOR BASIC DC-DC CONVERTERS- PART II 9

Introduction, Linear Feedback Control- Pole Placement by Full State Feedback, Pole Placement Based on Observer Design, Reduced Order Observers, Generalized Proportional Integral Controllers- Hamiltonian Systems Viewpoint - Application to power converters

UNIT III CONTROLLER DESIGN FOR BASIC AC-DC CONVERTER CIRCUITS 9

Introduction, Operating Principle of Single-Phase PFCs, Control of PFCs, Designing the Inner Average-Current-Control Loop, Designing the Outer Voltage-Control Loop, Example of Single-Phase PFC Systems

UNIT IV SLIDING MODE CONTROL 9

Introduction, Variable Structure Systems, Control of Single Switch Regulated Systems, Sliding Surfaces, Equivalent Control and the Ideal Sliding Dynamics, Accessibility of the Sliding Surface, Invariance Conditions for Matched Perturbations- Application to power converters

UNIT V FLATNESS BASED CONTROL 9

Flatness, the use of the differential flatness property, Controller development using flatness- Application to power converters

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1 Ability to design controller for front end power factor corrector circuits
CO2 Ability to design controllers for UPS application.
CO3 Ability to design controllers for AC-DC converters
CO4 Ability to design sliding mode control for power converters
CO5 Ability to design flatness based control for power converters.

TEXT BOOKS:

1. Control Design Techniques in Power Electronics Devices, HeberttSira-Ramírez and Ramón Silva-Ortigoza, Springer-Verlag London Limited 2006.
2. Power Electronics: A First Course, Ned Mohan, Johnwiley, 2011.
3. Laboratory Manual For Pulse-Width Modulated DC–DC Power Converters, Marian K. Kazimierczuk and Agasthya Ayachit, Wiley 2016

REFERENCES:

1. Dynamics and Control of DC-DC Converters, FarzinAsadi and Kei Eguchi, Morgan & Claypool, 2018.
2. Dynamic Analysis of Switching-Mode DC/DC Converters, Andre Kislovski, Springer 1991

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	✓		✓					
CO2	✓	✓	✓	✓	✓	✓	✓				✓	
CO3	✓	✓	✓	✓	✓	✓	✓				✓	✓
CO4	✓	✓	✓	✓	✓	✓	✓				✓	✓
CO5	✓		✓	✓	✓	✓	✓				✓	✓

Attested

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PE5071	MICROCONTROLLER BASED SYSTEM DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To get Introduced to the fundamentals of microcontroller based system design.
- To learn I/O and other built in features available in microcontroller.
- To know Microcontroller based system design, applications.
- To learn I/O interface in system Design
- To involve Discussions/ Practice/Exercise onto revising & familiarizing the concepts acquired for improved employability skills

UNIT I 8051 ARCHITECTURE 9

Architecture – memory organization – addressing modes – instruction set – Timers - Interrupts - I/O ports, Interfacing I/O Devices – Serial Communication.

UNIT II 8051 PROGRAMMING 9

Assembly language programming – Arithmetic Instructions – Logical Instructions –Single bit Instructions – Timer Counter Programming – Serial Communication Programming Interrupt Programming – LCD digital clock/thermometer. Introduction to IDE based assembler programming.

UNIT III PIC MICROCONTROLLER 9

Architecture – memory organization – addressing modes – instruction set – PIC progrmming in Assembly & C –I/O port, Data Conversion, RAM & ROM Allocation, Timer programming, practice in MP-LAB.

UNIT IV PERIPHERAL OF PIC MICROCONTROLLER 9

Timers – Interrupts, I/O ports- I2C bus-A/D converter-UART- CCP modules -ADC, DAC and Sensor Interfacing –Flash and EEPRO Memories.

UNIT V SYSTEM DESIGN –CASE STUDY 9

Interfacing LCD Display – Keypad Interfacing - Generation of Gate signals for converters and Inverters - Motor Control – Controlling DC/ AC appliances – Measurement of frequency - Standalone Data Acquisition System.

TOTAL: 45 PERIODS

COURSE OUTCOME:

CO1 Ability to understand the features of microcontroller 8051
CO2 Ability to write programs using 8051 assemble language, utilizing its build in features
CO3 Ability to understand the features of PIC microcontroller.
CO3 Ability to use the peripherals builtin the PIC microcontroller through programming
CO4 Ability to grasp the interfacing concepts involving in the design of microcontroller based systems.

	O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	O11	O12
O1	✓				✓	✓			✓		✓	
O2	✓				✓	✓			✓		✓	✓
O3	✓				✓	✓			✓		✓	
O4	✓				✓	✓			✓			✓
O5		✓	✓	✓			✓	✓	✓			✓

Attested

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TEXTBOOKS:

1. Kenneth J Ayala, “The 8051 Microcontroller”, Thomson press, 2007
2. Muhammad Ali Mazidi, RolinD.Mckinlay, Danny Causey ‘ PIC Microcontroller and Embedded Systems using Assembly and C for PIC18’, Pearson Education 2008

REFERENCES:

1. Rajkamal, ”Microcontrollers Architecture, Programming, Interfacing & System Design, Pearson, 2012.
2. MykePredko, “Programming and customizing the 8051 microcontroller”, Tata McGraw Hill 2001
3. Muhammad Ali Mazidi, SarmadNaimi, SepehrNaimi,” The AVR Microcontroller and Embedded Systems’ Using Assembly & C, PearsonEducation,2014
4. Muhammad Ali Mazidi, Janice G. Mazidi and Rolin D. McKinlay, ‘The 8051 Microcontroller and Embedded Systems’ Prentice Hall,2005.
5. John Iovine, ‘PIC Microcontroller Project Book ’, McGraw Hill2000

PE5072	ADVANCED POWER CONVERTERS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To study the operation of voltage lift circuits
- To study the operation of super lift circuits.
- To study the operation of ultra lift converters and multiple quadrant converters
- To study the principle of bidirectional dual active bridge converters
- To study the working principle of Impedance source converter.

UNIT I VOLTAGE-LIFT CONVERTERS 9

Introduction- Self-lift and reverse self-lift circuits- Cuk converter, Luo converter and SEPIC converters- continuous and discontinuous conduction mode.

UNIT II POSITIVE OUTPUT &NEGATIVE OUTPUT SUPER-LIFT LUO-CONVERTERS 9

Main series, -Elementary Circuit, Re-Lift Circuit, Triple-Lift Circuit, Higher-Order Lift Circuit-. Continuous conduction and discontinuous conduction mode.

UNIT III ULTRA LIFT CONVERTERS AND MULTIPLE-QUADRANT OPERATING LUO-CONVERTERS 9

Ultra-Lift Luo- Converter- Operation - Continuous conduction and discontinuous conduction Mode and of Ultra-Lift Luo-Converter-Instantaneous Values- Multiple quadrant operating Luo Converters- Circuit explanations-modes of operation

UNIT IV BIDIRECTIONAL DUAL ACTIVE BRIDGE DC–DC CONVERTERS 9

Application of Bidirectional DC–DC Converter-Classification of Bidirectional DC–DC Converter -Working Principle of Hybrid-Bridge-Based Dual active bridge (DAB) converter-Performance- Voltage match control- Principle of Dual-Transformer based DAB converter-Three-Level bidirectional DC–DC converter

UNIT V IMPEDANCE SOURCE CONVERTER 9

Voltage-Fed Z-source inverters -Topologies –Steady state and dynamic model- Current fed Z-source inverter -Topology -Modification and operational principles.

Modulation Methods- Sine PWM- SVPWM and Pulse width Amplitude Modulation

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TOTAL : 45 PERIODS

COURSE OUTCOMES:

CO1Ability to understand the working of voltage lift circuits.
CO2 Ability to design super lift converters
CO3 Ability to design ultra-lift converters
CO4 Ability to understand the working and design of bi-directional DC-DC converters
CO5 Ability to understand the concepts related with impedance source converter

TEXT BOOKS:

1. Advanced DC/DC Converters,2nd Edition,Fang Lin Luo, Hong Ye, CRC press,2018
2. Impedance source power electronic converters, Yushan Liu , Haitham Abu-Rub , BaomingGe , Dr. Frede Blaabjerg , Omar Ellabban , Poh Chiang Loh, Wiley IEEE press, 2016.
3. High-Frequency Isolated Bidirectional Dual Active Bridge DC–DC Converters with Wide Voltage Gain, Deshang Sha,GuoXu, Springer 2019.

REFERENCES:

1. Essential DC/DC Converters, 1st Edition, Fang Lin Luo, Hong Ye, CRC,2005
2. Power Electronics Advanced Conversion Technologies, Second Edition, Fang Lin Luo, Hong Ye, 2018 CRC press.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	✓	✓	✓					
CO2	✓	✓	✓	✓	✓	✓	✓				✓	
CO3	✓	✓	✓	✓	✓	✓	✓				✓	✓
CO4	✓	✓	✓	✓	✓	✓	✓				✓	✓
CO5	✓		✓	✓	✓	✓	✓				✓	✓

PE5073	POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

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

UNIT I INTRODUCTION **9**

Introduction to renewable energy systems, environmental aspects of electric energy conversion, impacts of renewable energy generation on environment, GHG Effect, Qualitative study of different renewable energy resources Ocean, Biomass, Hydrogen

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energy systems and Fuel cells.

UNIT II POWER ELECTRONIC CONVERTERS FOR RENEWABLE ENERGY 9

Solar: Block diagram of solar photo voltaic system: line commutated converters (inversion mode) - Boost and buck-boost converters.
Wind: three phase AC voltage controllers- AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, Grid Interactive Inverters-matrix converters.

UNIT III PHOTO VOLTAIC ENERGY CONVERSION SYSTEMS 9

Introduction, Photo Voltaic (PV) effect, Solar Cell, Types, Equivalent circuit of PV cell, PV cell characteristics (I/V and P/V) for variation of insolation, temperature and shading effect, Stand-alone PV system, Grid connected PV system, Design of PV system-load calculation, array sizing, selection of converter/inverter, battery sizing.

UNIT IV WIND ENERGY CONVERSION SYSTEMS 9

Introduction, Power contained in wind, Efficiency limit in wind, types of wind turbines, Wind control strategies, Power curve and Operating area, Types of wind generators system based on Electrical machines-Induction Generator and Permanent Magnet Synchronous Generator(PMSG), Grid Connected-Single and Double output system, Self-excited operation of Induction Generator and Variable Speed PMSG.

UNIT V HYBRID RENEWABLE ENERGY SYSTEMS AND MPPT 9

Energy Storage systems, Need for Hybrid Systems, Features of Hybrid Systems, Range and types of Hybrid systems (Wind-Diesel, PV-Diesel and Wind-PV), Case studies of PV-Maximum Power Point Tracking (MPPT) and Wind Energy system

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1 Ability to understand different renewable energy systems
CO2 Ability to design and simulate power electronics converters used for interfacing Renewable energy systems
CO3 Ability to design standalone renewable energy system employing embedded energy storage and MPPT strategy.
CO4 Ability to design grid connected renewable energy system.
CO5 Ability to extract maximum power using different MPPT algorithms

TEXTBOOKS:

1. S.N.Bhadra, D. Kastha, & S. Banerjee “Wind Electrical Systems”, Oxford University Press, 2009.
2. Haitham Abu-Rub, Mariusz Malinowski and Kamal Al-Haddad, “Power Electronics for Renewable Energy Systems, Transportation and Industrial Applications”, IEEE Press and John Wiley & Sons Ltd Press, 2014.

REFERENCES:

1. Rashid .M. H “power electronics Hand book”, Academic press, 2001.
2. Rai. G.D, “Non-conventional energy sources”, Khanna publishes, 1993.
3. Rai. G.D,” Solar energy utilization”, Khanna publishes, 1993.
4. Gray, L. Johnson, “Wind energy system”, prentice hall linc, 1995.
5. Non-conventional Energy sources B.H.Khan Tata McGraw-hill Publishing Company, New Delhi.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1						✓	✓	✓			✓	
CO2	✓	✓	✓	✓								
CO3	✓	✓	✓	✓					✓			
CO4	✓	✓	✓	✓								
CO5	✓	✓	✓	✓								

PE5074 **POWER QUALITY** **L T P C**
3 0 0 3

COURSE OBJECTIVES:

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

UNIT I INTRODUCTION 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 II ANALYSIS OF SINGLE PHASE AND THREE PHASE SYSTEM 9

Single phase linear and non linear loads –single phase sinusoidal, non sinusoidal source – supplying linear and nonlinear load – 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 III 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 of real and reactive powers – Extraction of fundamental sequence component from measured.

UNIT IV 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

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UNIT V SERIES COMPENSATION OF POWER DISTRIBUTION SYSTEM 9

Rectifier supported DVR – Dc Capacitor supported DVR – DVR Structure – voltage Restoration – Series Active Filter – Unified power quality conditioner.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1 Ability to understand consequences of Power quality issues.
CO2 Ability to conduct harmonic analysis of single phase and three phase systems supplying nonlinear loads.
CO3 Ability to design passive filter for load compensation.
CO4 Ability to design active filters for load compensation.
CO5 Ability to understand the mitigation techniques using custom power devices such as distribution static compensator (DSTATCOM), dynamic voltage restorer (DVR)& UPQC.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓										
CO2	✓	✓					✓					
CO3	✓	✓					✓					
CO4	✓	✓					✓					
CO5	✓	✓					✓					

TEXTBOOKS:

1. Arindam Ghosh “Power Quality Enhancement Using Custom Power Devices”, Kluwer Academic Publishers,2002
2. G.T.Heydt, “Electric Power Quality”, Stars in a Circle Publications, 1994(2ndedition)

REFERENCES:

1. Power Quality - R.C.Duggan
2. Power system harmonics –A.J.Arrillga
3. Power Electronic Converter Harmonics –Derek A.Paice

PW5071 ELECTRIC VEHICLES AND POWER MANAGEMENT LT P C
3 0 0 3

COURSE OBJECTIVES:

- To provide knowledge about electric vehicle architecture and power train components.
- To know the concepts of dynamics of electrical vehicles
- To impart knowledge on vehicle control for standard drive cycles of hybrid electrical vehicles (HEVs)
- To understand the concept of energy storage systems.
- To provide knowledge about different energy sources and energy management in HEVs.

UNIT I HYBRID ELECTRIC VEHICLE ARCHITECTURE AND POWER TRAIN COMPONENTS 9

History of evolution of Electric Vehicles - Comparison of Electric Vehicles with Internal Combustion Engines - Architecture of Electric Vehicles (EV) and Hybrid Electric Vehicles (HEV) – Plug-in Hybrid Electric Vehicles (PHEV)- Power train components and sizing, Gears, Clutches, Transmission and Brakes.

UNIT II MECHANICS OF HYBRID ELECTRIC VEHICLES 9

Fundamentals of vehicle mechanics - tractive force, power and energy requirements for standard drive cycles of HEV's - motor torque and power rating and battery capacity.

UNIT III CONTROL OF DC AND AC MOTOR DRIVES 9

Speed control for constant torque, constant HP operation of all electric motors - DC/DC chopper based four quadrant operation of DC motor drives, inverter based V/f Operation (motoring and braking) of induction motor drives, vector control operation of Induction motor and PMSM, Brushless DC motor drives, Switched reluctance motor (SRM) drives

UNIT IV ENERGY STORAGE SYSTEMS 9

Battery: Principle of operation, types, models, estimation of parameters, battery modeling, SOC of battery, Traction Batteries and their capacity for standard drive cycles, Vehicle to Grid operation of EV's. **Alternate sources:** Fuel cells, Ultra capacitors, Fly wheels.

UNIT V HYBRID VEHICLE CONTROL STRATEGY AND ENERGY MANAGEMENT 9

HEV supervisory control - Selection of modes - power spilt mode - parallel mode - engine brake mode - regeneration mode - series parallel mode - energy management of HEV's.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Learned the electric vehicle architecture and power train components.
CO2: Acquired the concepts of dynamics of electrical vehicles
CO3: Able to understand the vehicle control for standard drive cycles of hybrid electrical vehicles (HEVs).
CO4: Ability to design and select energy storage systems.
CO5: Acquired the knowledge of different energy sources and energy management in HEVs.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓			✓							
CO2	✓	✓	✓						✓			
CO3	✓			✓		✓	✓					
CO4	✓	✓	✓		✓							
CO5	✓		✓								✓	

REFERENCES:

1. Iqbal Husain, 'Electric and Hybrid Electric Vehicles', CRC Press, 2011.
2. Wei Liu, 'Hybrid Electric Vehicle System Modeling and Control', Second Edition, WILEY, 2017.
3. James Larminie and John Lowry, 'Electric Vehicle Technology Explained', Second Edition, 2012.

PW5074 ENERGY STORAGE TECHNOLOGIES LT P C
3 0 0 3

COURSE OBJECTIVES:

- To understand the various types of energy storage Technologies.
- To analyze thermal storage system.
- To analyze different battery storage technologies
- To analyze the thermodynamics of Fuel Cell

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- To study the various applications of energy storage systems.

UNIT I INTRODUCTION 9

Necessity of energy storage – types of energy storage – comparison of energy storage technologies – Applications.

UNIT II THERMAL STORAGE SYSTEM 9

Thermal storage – Types – Modeling of thermal storage units – Simple water and rock bed storage system – pressurized water storage system – Modelling of phase change storage system – Simple units, packed bed storage units - Modelling using porous medium approach, Use of TRNSYS.

UNIT III ELECTRICAL ENERGY STORAGE 9

Fundamental concept of batteries – measuring of battery performance, charging and is charging of a battery, storage density, energy density, and safety issues. Types of batteries – Lead Acid, ickel – Cadmium, Zinc Manganese dioxide - Mathematical Modelling for Lead Acid Batteries – Flow Batteries.

UNIT IV FUEL CELL 9

Fuel Cell – History of Fuel cell, Principles of Electrochemical storage – Types – Hydrogen oxygen cells, Hydrogen air cell, Hydrocarbon air cell, alkaline fuel cell, detailed analysis – advantages and disadvantages –Fuel Cell Thermodynamics.

UNIT V ALTERNATE ENERGY STORAGE TECHNOLOGIES 9

Flywheel , Super capacitors, Principles & Methods – Applications, Compressed air Energy storage, Concept of Hybrid Storage – Applications, Pumped Hydro Storage – Applications.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Gained knowledge of various storage technologies.
CO2: Able to design a thermal storage system.
CO3: Ability to model battery storage system.
CO4: Learned to analyze the thermodynamics of fuel cell.
CO5: Gained Knowledge of various applications of storage technologies and perform the selection based on techno-economic view point.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓										
CO2			✓									
CO3			✓									
CO4			✓									
CO5	✓		✓									

REFERENCES

1. Ibrahim Dincer and Mark A. Rosen, 'Thermal Energy Storage Systems and Applications', JohnWiley & Sons 2002.
2. James Larminie and Andrew Dicks, 'Fuel cell systems Explained', Wiley publications, 2003.
3. Lunardini.V.J, 'Heat Transfer in Cold Climates', John Wiley and Sons 1981.
4. Ru-shiliu, Leizhang and Xueliang sun, 'Electrochemical technologies for energy storage and conversion', Wiley publications, 2012.
5. Schmidt.F.W. and Willmott.A.J., 'Thermal Storage and Regeneration', Hemisphere Publishing Corporation, 1981.

PW5075 GRID INTEGRATION OF RENEWABLE ENERGY SOURCES LT P C
3 0 0 3

COURSE OBJECTIVES:

- To study about the integration of various renewable energy sources into the grid.
- To analyse various grid issues due to renewable energy sources.
- To analyse the dynamics of network due to wind farm
- To provide knowledge about power system stabilizers.
- To provide knowledge about grid connected and standalone PV system

UNIT I INTRODUCTION 9

Introduction to renewable energy grid integration - Concept of mini/micro grids and Smart grids - Different types of grid interfaces - Issues related to grid integration of small and large scale of synchronous generator based - induction generator based and converter based sources together - Network voltage management - Power quality management (voltage dips, harmonics, flickers, and reactive power control) - Frequency management - Influence of WECS on system transient response - Interconnection standards and grid code requirements for integration.

UNIT II NETWORK INFLUENCE OF GENERATION TYPE 9

starting – Network voltage management – Thermal/Active power management – Network power quality management – Transient system performance – Fault level issues – Protection.

UNIT III INFLUENCE OF WIND FARMS ON NETWORK DYNAMIC PERFORMANCE 9

Dynamic Stability and its Assessment – Dynamic characteristics of Synchronous Generation - A Synchronizing power and Damping power model of a Synchronous Generator – Influence of Automatic Voltage Regulator on Damping – Influence on Damping of Generator Operating Conditions – Influence of Turbine Governor on Generator Operation – Transient Stability – Voltage Stability – Influence of Generation Type on Network Dynamic Stability – Dynamic Interaction of Wind Farms with the Network – influence of Wind Generation on Network Transient Performance.

UNIT IV POWER SYSTEM STABILIZERS AND NETWORK DAMPING CAPABILITY OF WIND 9

A Power System Stabilizer for a Synchronous Generator - A Power System Stabilizer for a DFIG - A Power System Stabilizer for a FRC Wind Farm.

UNIT V STAND ALONE AND GRID CONNECTED PV SYSTEM 9

Solar modules – storage systems – Basics of batteries – Batteries for PV Systems – Charge Controllers – MPPT and Inverters – Power Conditioning and Regulation – protection – Types of Solar PV systems - standalone PV systems design – sizing – PV systems in buildings – design issues for central power stations – safety – Economic aspect – efficiency and performance – International PV programs

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Know about the integration of various renewable energy sources into the grid.
CO2: Able to analyze various grid issues due to renewable energy sources.
CO3: Able to analyze the dynamics of network due to windfarm
CO4: Know about power system stabilizers.
CO5: Able to design the grid connected and standalone PV system.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2		✓										
CO3		✓										
CO4		✓										
CO5			✓									

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REFERENCES

1. Stuart R.Wenham, Martin A. Green, Muriel E. Watt and Richard Corkish, 'Applied Photovoltaics', Earthscan, UK, 2007.
2. Joshua Earnest, 'Wind power technology', II Edition, PHI, 2015.
3. Olimpo Anaya-Lara, Nick Jenkins, Janaka Ekanayake, Phill Cartwright and Mike Hughes, 'WIND GENERATIONModelling and Control', A John Wiley and Sons, Ltd., Publication, 2009.
4. Brenden Fox, Damian Flynn and Leslie Bryans, 'Wind Power Integration Connection and system operational aspects', Published by The Institute of Engineering and Technology, London, United Kingdom, 2007.
5. Frank S. Barnes & Jonah G.Levine, 'Large Energy Storage Systems Handbook', CRC Press, 2011.
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7. Chetan Singh Solanki, 'Solar Photovoltaic Technology and Systems' – A Manual for Technicians, Trainees and Engineers, PHI, 2014.

PW5076 MICRO-GRID OPERATION AND CONTROL LT P C
3 0 0 3

COURSE OBJECTIVES:

- To illustrate the concept of micro sources and storage.
- To study concept of AC microgrid and its controllers.
- To study concept of DC microgrid and its controllers.
- To study concept of hybrid microgrid and its controllers.
- To study concept of islanding and impact on protection.

UNIT I MICRO SOURCES AND STORAGE 9

Microgrid Structure and Operating Modes – Solar PV – Wind Energy – Fuel Cell –Battery – Super capacitor

UNIT II AC MICROGRID 9

Hierarchical Control: Primary, Secondary and Tertiary Control– Primary Control: Droop Control, Virtual Synchronous Generator Control for VSC – Secondary Control – Simulation Studies

UNIT III DC MICROGRID 9

Hierarchical Control: Primary, Secondary and Tertiary Control – Primary Control: Droop Control, Virtual Inertia Control – Secondary Control: Centralized and Decentralized Control – Simulation Studies

UNIT IV HYBRID MICROGRID 9

Hybrid AC/DC Microgrid Structure: AC Coupled, DC Coupled, AC-DC Coupled –Control Strategies: different modes of operation, during transition – Simulation Studies

UNIT V MICROGRID PROTECTION 9

Protection: Effect on Relay Protection of distribution network, Differential Relay Protection, Directional Impedance Relay Protection– Islanding: Active and Passive Techniques– Earthing: Requirements, Earthing mode of DG in TN/TT Earthing System, Earthing mode of DG in IT

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Ability to analyze micro-sources and storage systems.
CO2: Able to analyse the configurations and control aspects of AC microgrid.

CO3: Understand and analyse the configurations and control aspects of DC microgrid.
CO4: Acquired knowledge about configurations and control aspects of Hybrid microgrid.
CO5: Learned the protection aspects of microgrid.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓						✓					
CO2	✓	✓	✓	✓	✓		✓					
CO3	✓	✓	✓	✓	✓		✓					
CO4	✓	✓	✓	✓	✓		✓					
CO5	✓		✓	✓								

REFERENCES:

1. H. Bevrani, Bruno Francois and ToshifumiIse, 'Microgrid Dynamics and Control', Wiley, 2017.
2. Li Fusheng, Li Ruisheng and Zhou Fengquan, 'Microgrid Technology and Engineering Application', Elsevier, 2016.
3. M.S. Mahmoud, 'Microgrid - Advanced Control Methods and Renewable Energy System Integration', Elsevier, 2017.
4. FarzamNejabatkhah and Yun Wei Li, 'Overview of Power Management Strategies of Hybrid AC/DC Microgrid', IEEE Transactions on Power Electronics, 2014.

PW5077 RENEWABLE ENERGY TECHNOLOGY LT P C
3 0 0 3

COURSE OBJECTIVES

- To Provide knowledge about various renewable energy technologies
- To enable students to understand and design a PV system.
- To provide knowledge about wind energy system.
- To Provide knowledge about various possible hybrid energy systems
- To gain knowledge about application of various renewable energy technologies

UNIT I INTRODUCTION 9

Primary energy sources, renewable vs. non-renewable primary energy sources, renewable energy resources in India, Current usage of renewable energy sources in India, future potential of renewable energy in power production and development of renewable energy technologies.

UNITII SOLAR ENERGY 9

Solar Radiation and its measurements, Solar Thermal Energy Conversion from plate Solar Collectors, Concentrating Collectors and its Types , Efficiency and performance of collectors, Applications of Solar Thermal Energy use of low and medium, high temperature and recent advances in industry and buildings. Direct Solar Electricity Conversion from Photovoltaic, types of solar cells and its application of battery charger, domestic lighting, street lighting, and water pumping, power generation schemes. Recent Advances in PV Applications: Building Integrated PV, Grid Connected PV Systems, Hybrid Systems and Solar Cars, Solar Energy Storage system and their economic aspects.

UNIT III WIND ENERGY 9

Wind energy principles, wind site and its resource assessment, wind assessment, Factors

influencing wind, wind turbine components, wind energy conversion systems (WECS), Classification of WECS devices, wind electric generating and control systems, characteristics and applications. Hybrid systems - safety and environmental aspects, economic aspects.

UNIT IV BIO-ENERGY **9**

Energy from biomass, Principle of biomass conversion technologies/process and their classification, Bio gas generation, types of biogas plants, selection of site for biogas plant, classification of biogas plants, Advantage and disadvantages of biogas generation, thermal gasification of biomass, biomass gasifies, Application of biomass and biogas plants and their economics.

UNIT V OTHER TYPES OF ENERGY **9**

Energy conversion from Hydrogen and Fuel cells, Geo thermal energy Resources, types of wells, methods of harnessing the energy, potential in India. OTEC, Principles utilization, setting of OTEC plants, thermodynamic cycles. Tidal and wave energy: Potential and conversion techniques, mini-hydel power plants and their economics.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Attained knowledge about various renewable energy technologies
CO2: Ability to understand and design a PV system.
CO3: Understand the concept of various wind energy system.
CO4: Gained knowledge about various possible hybrid energy systems
CO5: Attained knowledge about various application of renewable energy technologies

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓		✓									
CO3	✓		✓									
CO4	✓		✓									
CO5			✓									

REFERENCES

1. Twidell & Wier,**'**Renewable Energy Resources' CRC Press(Taylor & Francis).
2. Tiwari and Ghosal/ Narosa,'Renewable energy resources'.
3. D.P.Kothari,K.C.Singhal,'Renewable energy sources and emerging technologies', P.H.I.
4. D.S.Chauhan, S.K. Srivastava, 'Non – Conventional Energy Resources', New Age Publishers, 2006.
5. B.H.Khan, 'Non – Conventional Energy Resources', Tata Mc Graw Hill, 2006.

PS5251 **HVDC AND FACTS**

L	T	P	C
3	1	0	4

COURSE OBJECTIVES

- To impart knowledge on the need for HVDC and FACTS.
- To impart in depth knowledge the operation, modelling and control of thyristor based FACTS controllers.
- To have an in-depth knowledge on the operation, modelling and control of LCC basedHVDC link.
- To have an in-depth knowledge on the operation, modelling and control of VSC basedHVDC link and FACTS controllers.
- To analyze the interaction of AC- DC systems through Power flow analysis.

UNIT I INTRODUCTION **12**

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-Review of basics of LCC and VSC HVDC system.

UNIT II THYRISTOR BASED FACTS **12**

Configuration of SVC- voltage regulation by SVC- Modelling of SVC for power flow analysis- Stability studies- Applications: transient stability enhancement and power oscillation damping of SMIB system with SVC connected at the mid-point of the line-Concepts of Controlled Series Compensation – Operation of TCSC- Analysis of TCSC – Modelling of TCSC for power flow and stability studies.

UNIT III ANALYSIS OF LCC HVDC CONVERTERS AND HVDC SYSTEM CONTROL **12**

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.

UNIT IV VOLTAGE SOURCE CONVERTER BASED FACTS AND HVDC CONTROLLERS **12**

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) - Modelling of UPFC and IPFC for power flow and transient stability studies- ApplicationsVSC based HVDC: Operation, Modelling for steady state and dynamic studies.

UNIT VPOWER FLOW ANALYSIS OF AC/DC SYSTEMS **12**

Per unit system for DC Quantities - Modelling of DC links - Solution of DC load flow-Solution of AC-DC power flow:Sequential and Simultaneous methods.

TOTAL: 60 PERIODS

COURSE OUTCOMES

Students will be able to:

CO1: Understand the basics of power transmission networks and need for HVDC and FACTS controllers.
CO2: Analyze the operation, control and application of thyristor based FACTS controllers.
CO3: Analyze the operation, control and application of LCC based HVDC link .
CO4: Analyze the operation, control and application of VSC based HVDC link .
CO5: Model HVDC and FACTS for Power Flow studies.

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MAPPING

	O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	O11	O12
O1	✓	✓	✓	✓	✓							
O2	✓	✓	✓	✓	✓							
O3	✓	✓	✓	✓	✓			✓				
O4	✓	✓	✓	✓	✓							
O5	✓	✓	✓	✓	✓	✓						✓

REFERENCES

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2. K.R.Padiyar, “HVDC Power Transmission Systems”, New Age International (P)Ltd., New Delhi, 2002.
3. Mohan Mathur, R., Rajiv. K. Varma, “Thyristor – Based Facts Controllers for Electrical Transmission Systems”, IEEE press and John Wiley& Sons, Inc.
4. K.R.Padiyar,” FACTS Controllers in Power Transmission and Distribution”, New Age International(P) Ltd., Publishers, New Delhi, Reprint 2008.
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9. Narain G.Hingorani, Laszio. Gyugyl, “Understanding FACTS Concepts and Technology of Flexible AC Transmission System”, Standard Publishers, Delhi 2001.

PS5075 **SMART GRID**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

Students will be able to:

- Understand concept of smart grid and its advantages over conventional grid
- Know smart metering techniques
- Learn wide area measurement techniques
- Understanding the problems associated with integration of distributed generation & its solution through smart grid.
- To familiarize the high performance computing for Smart Gridapplications

UNIT I INTRODUCTION TO SMART GRID **9**

Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, Functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, National and International Initiatives in Smart Grid.

UNIT II SMART GRID TECHNOLOGIES (Transmission) **9**

Technology Drivers, Smart energy resources, Smart substations, Substation Automation, Feeder Automation, Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control

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UNIT III SMART GRID TECHNOLOGIES (Distribution) 9

DMS, Volt/VAr control, Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, and Plug in Hybrid Electric Vehicles (PHEV).

UNIT IV SMART METERS AND ADVANCED METERING INFRASTRUCTURE 9

Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits,AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit (PMU), Intelligent Electronic Devices (IED) & their application for monitoring & protection.

UNIT V HIGH PERFORMANCE COMPUTING FOR SMART GRID APPLICATIONS 9

Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), IP based Protocols, Computing algorithms for Smart grid, IOT, Cyber Security for Smart Grid.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Students will be able to:

CO1:Understand on the concepts of Smart Grid and its present developments.

CO2:Analyze about different Smart Grid transmission technologies.

CO3:Analyze about different Smart Grid distribution technologies.

CO4:Acquire knowledge about different smart meters and advancedmetering infrastructure.

CO5:Develop more understanding on LAN, WAN and Cloud Computing for Smart Grid applications.

	O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	O11	O12
O1	✓				✓	✓	✓					
O2	✓				✓	✓	✓					
O3	✓				✓	✓	✓					
O4	✓				✓	✓	✓					
O5	✓				✓	✓	✓			✓		

REFERENCES

1. Stuart Borlase “Smart Grid :Infrastructure, Technology and Solutions”, CRC Press 2016.
2. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, “Smart Grid: Technology and Applications”,Wiley.
3. Vehbi C. Gungor, Dilan Sahin, Taskin Kocak, Salih Ergut, Concettina Buccella,Carlo Cecati, and Gerhard P. Hancke, Smart Grid Technologies: Communication Technologies and Standards IEEE Transactions On Industrial Informatics, Vol. 7, No. 4, November 2011.

PS5076 WIND ENERGY CONVERSION SYSTEM LT 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 understand the concepts of fixed speed wind energy conversion systems.
- To understand the concepts of Variable speed wind energy conversion

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systems.

- To analyze the grid integration issues.

UNITI INTRODUCTION **9**

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

UNIT II WINDTURBINES **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 III FIXEDSPEEDSYSTEMS **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 IV VARIABLESPEED SYSTEMS **9**

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

UNIT V GRIDCONNECTED 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

Students will be able to:

CO1: Attain knowledge on the basic concepts of Wind energy conversion system.

CO2: Attain the knowledge of the mathematical modelling and control of the Wind turbine

CO3: Develop more understanding on the design of Fixed speed system

CO4: Study about the need of Variable speed system and its modelling.

CO5: Learn about Grid integration issues and current practices of wind interconnections with power system.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓		✓		✓							
CO3	✓		✓									
CO4	✓		✓		✓							
CO5	✓	✓	✓	✓								

REFERENCES

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2. S.N.Bhadra, D.Kastha,S.Banerjee, "Wind Electrical Systems", Oxford University Press,2010.
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6. S.Heir "Grid Integration of WECS", Wiley1998.

PS5073	DISTRIBUTED GENERATION CONTROL AND AUTOMATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

Students will be able to:

- learn about distributed generation (DG) and distribution automation
- gain knowledge about planning and designing of distribution system
- understand the concepts of grid integration and control of DG
- familiarize the concepts of economic aspects of DG
- analyze the application of SCADA in automation

UNIT I DISTRIBUTED GENERATION 9

Introduction, Distributed Generation Definition, Distributed generation advantages, challenges and needs, Distributed Generation Units- Micro turbines, Reciprocating Engines, Wind generators, Photovoltaic generators, Hydro generation, Fuel cells, Biomass and other technologies. Energy Storage-batteries, Flywheels, Ultra Capacitors.

UNIT II GRID INTEGRATION AND CONTROL OF DG 9

Recent trends in power electronic DG interconnection. General power electronic DG interconnection topologies for various sources and control. Control of DG inverters, current control and DC voltage control for stand-alone and grid parallel operations. Protection of the converter, Control of grid interactive power converters, phase locked loops ,synchronization and phase locking techniques, current control, DC bus control during grid faults, converter faults during grid parallel and stand-alone operation.

UNIT III ISSUES AND ECONOMIC ASPECTS OF DG 9

Intentional and unintentional islanding of distribution systems. Passive and active detection of unintentional islands, non-detection zones. Reactive power support using DG. Power quality improvement using DG, Power quality issues in DG environment. Economic aspects of DG-Generation cost, investment, tariffs analysis. Hybrid energy systems. Distributed generation in the Indian scenario – case studies.

UNIT IV IMPLEMENTATION OF SCADA IN AUTOMATION 9

Introduction to SCADA, Monitoring and supervisory functions, SCADA applications in Utility Automation, SCADA System Components, RTU, IED, PLC, Communication Network, SCADA Server, SCADA/HMI Systems, Various SCADA architectures, single unified standard architecture-IEC 61850, SCADA Communication, open standard communication protocols.

UNIT V DISTRIBUTION AUTOMATION AND COMPONENTS 9

Distribution automation planning, communication, Wireless and wired Communications-DA Communication Protocols, Architectures and user interface, sensors, Supervisory Control and Data Acquisition Systems (SCADA), Case Studies.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Students will be able to:

CO1:describe the principle and operation of different distributed generation

CO2:Attain knowledge in grid integration of distributed generation and control and will enhance their capability of planning and designing of distribution system.

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CO3:analyze the impact of distributed generators on the performance of distribution system
CO4:gain knowledge about SCADA in automation
CO5:familiarize with the components of distribution automation

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓	✓	✓	✓			✓					
CO3	✓	✓	✓	✓								
CO4	✓			✓		✓						
CO5	✓					✓						

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2. D.Mukherjee, and S.Chakrabarti, ”Fundamentals of renewable energy systems", New Age International Pvt Ltd Publishers, 2007.
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5. Godfrey Boyle,"Renewable energy:Power for a sustainable future”, Oxford University Press, 2012.
6. IEEE Press: IEEE Recommended practice for Electric Power Distribution for Industrial Plants,
   IEEE, Inc., 1994

PS5074 OPTIMISATION TECHNIQUES L T P C
3 0 0 3

COURSE OBJECTIVES

Students will be able to:

- understand the classification of optimization
- study the linear programming models and solution techniques
- study the different non-linear programming problem solution techniques
- understand the concept of dynamic programming
- study the fundamentals genetic algorithm and it applications.

UNITI INTRODUCTION 9

Definition, Classification of optimization problems, Classical Optimization Techniques, Single and Multiple Optimization with and without inequality constraints.

UNITII LINEAR PROGRAMMING (LP) 9

Simplex method of solving LPP, revised simplex method, duality, Constrained optimization, Theorems and procedure, Linear programming, mathematical model, solution technique, duality.

UNITIII NON LINEAR PROGRAMMING 9

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

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UNITIV DYNAMIC PROGRAMMING (DP) 9

Multistage decision processes, concept of sub-optimization and principle of optimality, Recursive relations, Integer Linear programming, Branch and bound algorithm

UNITV GENETIC ALGORITHM 9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES

Students will be able to:

CO1:learn about different classifications of optimization problems and techniques.

CO2:attain knowledge on linear programming concepts

CO3:understand the application of non-linear programming in optimization techniques

CO4:understand the fundamental concepts of dynamic programming

CO5:gain knowledge about Genetic algorithm and its application topower system optimization.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓	✓										
CO3	✓	✓										
CO4	✓	✓										
CO5	✓	✓			✓							

REFERENCE BOOKS

1. S.S. Rao, "Engineering Optimization – Theory and Practice", John Wiley & Sons, Inc.,2009.
2. Hamdy A. Taha, Operations Research: An Introduction, 10th Edition, Pearson, 2016.
3. David G. Luenberger, "Introduction to Linear and Nonlinear Programming", Addison-Wesley, 1973.
4. E. Polak, "Computational methods in Optimization", Academic Press,1971.
5. Pierre D.A., "Optimization Theory with Applications", Wiley Publications,1969.

CO5152 INTELLIGENT CONTROLLERS L T P C
3 0 0 3

COURSE OBJECTIVES

To educate the students on

- Design of ANN and fuzzy set theory.
- Analysis and implementation of ANN and Fuzzy logic for modeling and control of Non-linear system and to get familiarized with the Matlab toolbox.
- Impart the knowledge of various optimization techniques and hybrid schemes with the ANFIS tool box.

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UNIT I OVERVIEW OF ARTIFICIAL NEURAL NETWORK (ANN) & FUZZY LOGIC 9

Review of fundamentals - Biological neuron, Artificial neuron, Activation function, Single Layer Perceptron – Limitations – Multi Layer Perceptron – Back propagation algorithm (BPA); Fuzzy set theory – Fuzzy sets – Operation on Fuzzy sets - Scalar cardinality, fuzzy cardinality, union and intersection, complement (yager and sugeno), equilibrium points, aggregation, projection, composition, fuzzy relation – Fuzzy membership functions.

UNIT II NEURAL NETWORKS FOR MODELLING AND CONTROL 9

Generation of training data - optimal architecture – Model validation- Control of non linear system using ANN- Direct and Indirect neuro control schemes- Adaptive neuro controller –Case study - Familiarization of Neural Network Control Tool Box.

UNIT III FUZZY LOGIC FOR MODELLING AND CONTROL 9

Modeling of nonlinear systems using fuzzy models(Mamdani and Sugeno) –TSK model - Fuzzy Logic controller – Fuzzification – Knowledge base – Decision making logic – Defuzzification- Adaptive fuzz y systems-Case study-Familiarization of Fuzzy Logic Tool Box.

UNIT IV GENETIC ALGORITHM 9

Basic concept of Genetic algorithm and detail algorithmic steps, adjustment of free parameters. Solution of typical control problems using genetic algorithm. Concept on some other search techniques like Tabu search, Ant-colony search and Particle Swarm Optimization.

UNIT V HYBRID CONTROL SCHEMES 9

Fuzzification and rule base using ANN–Neuro fuzzy systems-ANFIS –Optimization of membership function and rule base using Genetic Algorithm and Particle Swarm Optimization - Case study– Familiarization of ANFIS Tool Box.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Ability to

CO1:Understand the basic architectures of NN and Fuzzy sets
CO2:Design and implement ANN architectures, algorithms and know their limitations.
CO3:Identify and work with different operations on the fuzzy sets.
CO4:Develop ANN and fuzzy logic based models and control schemes for non-linear systems.
CO5:Understand and explore hybrid control schemes and PSO

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓			✓						✓
CO2	✓	✓	✓			✓						
CO3	✓	✓	✓			✓						✓
CO4	✓	✓	✓			✓						✓
CO5	✓	✓	✓			✓						✓

REFERENCES:

1. LaureneV.Fausett, “Fundamentals of Neural Networks, Architecture, Algorithms, and Applications”, Pearson Education, 2008.
2. Timothy J.Ross, “Fuzzy Logic with Engineering Applications”, Wiley, Third Edition, 2010.
3. David E.Goldberg, “Genetic Algorithms in Search, Optimization, and Machine Learning”, Pearson Education, 2009.
4. W.T.Miller, R.S.Sutton and P.J.Webrose, “Neural Networks for Control”, MIT Press, 1996.

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5. George J.Klir and Bo Yuan, “Fuzzy Sets and Fuzzy Logic: Theory and Applications”, Prentice HalI, First Edition, 1995.

CO5153 MEMS DESIGN:SENSORS AND ACTUATORS LT P C
3 0 0 3

COURSE OBJECTIVES

- To analyse the properties of materials, microstructure and fabrication methods.
- To design and modeling of Electrostatic sensors and actuators.
- To teach the characterizing thermal sensors and actuators through design and modeling.
- To understand the fundamentals of piezoelectric sensors and actuators through exposure to different MEMS and NEMS devices

UNIT I MICRO-FABRICATION, MATERIALS AND ELECTRO-MECHANICAL CONEPTS 9
Overview of micro fabrication – 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 II ELECTROSTATIC SENSORS AND ACTUATION 9
Principle, material, design and fabrication of parallel plate capacitors as electrostatic sensors and actuators-Applications

UNIT III THERMAL SENSING AND ACTUATION 9
Principle, material, design and fabrication of thermal couples, thermal bimorph sensors, thermal resistor sensors-Applications.

UNIT IV PIEZOELECTRIC SENSING AND ACTUATION 9
Piezoelectric effect-cantilever piezo electric actuator model-properties of piezoelectric materials Applications.

UNIT V CASE STUDIES 9
Piezoresistive sensors, Magnetic actuation, Micro fluidics applications, Medical applications, Optical MEMS.-NEMS Devices

TOTAL : 45 PERIODS

COURSEOUTCOMES:
At the end of this course, the students will demonstrate the ability

CO1:To analyse the learning process to design of micro sensors, embedded sensors & actuators
CO2:To analyse the electrostatic sensors and actuators through MEMS and NEMS devices
CO3:To analyse the thermal sensors and actuators through MEMS and NEMS devices
CO4:To analyse the piezoelectric sensors and actuators through MEMS and NEMS
CO5:Design of piezoresistive sensors for biomedical and micro fluidic applications

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓						✓			✓
CO2	✓	✓	✓						✓			✓
CO3	✓	✓	✓						✓			✓
CO4	✓	✓		✓		✓						✓
CO5	✓	✓		✓			✓					

Attested

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REFERENCES
1. Chang Liu, “Foundations of MEMS”, Pearson International Edition, 2006.
2. Marc Madou , “Fundamentals of microfabrication”,CRC Press, 1997.
3. Boston , “Micromachined Transducers Source book”,WCB McGraw Hill, 1998.
4. M.H.Bao “Micromechanical transducers: Pressure sensors, accelerometers and gyroscopes”, Elsevier, Newyork, 2000.

CO5151 CONTROL SYSTEM DESIGN

L	T	P	C
4	0	0	4

COURSE OBJECTIVES

To educate the students on

- Analysis and design of controllers for linear systems defined in transfer function and state space from.
- Application of optimal control and filtering concepts for linear systems continuous and discrete domain.

UNIT I ANALYSIS OF LINEAR SYSTEMS 12

Review of system models –Transfer function and state space form– Time and Frequency Response – stability- Discretization –Need for Discretization –Sample and Hold devices – Effect of sampling on transfer function and state models – Analysis – Test for controllability and Observability.

UNIT II DESIGN OF SISO SYSTEM 12

Design Specifications –In continuous domain – Limitations – Controller Structure – Multiple degrees of freedom – PID controllers and Lag-lead compensators- Design – Discretization and direct discrete design - Design in continuous and discrete domain

UNIT III STATE SPACE DESIGN 12

Pole assignment design – State and Output Feedback – observers – Estimated State Feedback – Design Examples (Continuous and Discrete).

UNIT IV OPTIMAL CONTROL 12

Introduction: Classical control and optimization, formulation of optimal control problem, Typical performance measures – Linear quadratic regulator problem – solution – Application examples.

UNIT V OPTIMAL FILTERING 12

Filtering – Linear system and estimation – System noise smoothing and prediction – Kalman Filter –Recursive estimation.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

Ability to

CO1:Analyse controllers for linear systems defined in transfer function and state space forms.

CO2:Design controllers for linear systems defined in transfer function and state space forms.

CO3:Apply state space forms to continuous and discrete systems.

CO4:Apply optimal control to linear systems in continuous and discrete systems

CO5:Apply filtering concepts to linear systems in continuous and discrete systems.

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓								
CO2	✓	✓	✓	✓								
CO3	✓	✓	✓	✓								
CO4	✓	✓	✓	✓								
CO5	✓	✓	✓	✓								

TEXT BOOKS:

1. M.Gopal, "Digital Control and State Variable Methods", 4th edition, McGraw Hill India, 2012
2. K. Ogata, 'Modern Control Engineering', 5th Edition, Pearson, 2012.
3. I. P. Mohandas, "Modern Control Engineering", Sanguine Technical Publishers, 2006.
4. Kirk D.E., 'Optimal Control Theory – An introduction',Prentice hall, N.J., 1970.
5. Sage, A.P., 'Optimum System Control', Prentice Hall N.H., 1968.
6. Anderson, BD.O. and Moore J.B., 'Optimal Filtering', Prentice hall Inc., N.J., 1979.

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4. T. Glad and L. Ljung, "Control Theory –Multivariable and Non-Linear Methods", Taylor & Francis, 2002.

CO5075 SYSTEM THEORY **LT P C 3 0 0 3**

COURSE OBJECTIVES

- To educate on modeling and representing systems in state variable form.
- To educate on solving linear and non-linear state equations.
- To illustrate the role of controllability and observability.
- To educate on stability analysis of systems using Lyapunov's theory.
- To educate on modal concepts and design of state and output feedback controllers and estimators.

UNIT I STATE VARIABLE REPRESENTATION 9

Introduction-Concept of State-State equation for Dynamic Systems -Time invariance and linearity-Non uniqueness of state model-State Diagrams - Physical System and State Assignment.

UNIT II SOLUTION OF STATE EQUATIONS 9

Existence and uniqueness of solutions to Continuous-time state equations-Solution of Nonlinear and Linear Time Varying State equations-Evaluation of matrix exponential-System modes- Role of Eigenvalues and Eigenvectors.

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UNIT III CONTROLLABILITY AND OBSERVABILITY 9

Controllability and Observability - Stabilizability and Detectability-Test for Continuous time Systems- Time varying and Time invariant case-Output Controllability-Reducibility-System Realizations.

UNIT IV STABILTY 9

Introduction-Equilibrium Points-Stability in the sense of Lyapunov-BIBO Stability-Stability of LTI Systems-Equilibrium Stability of Nonlinear Continuous Time Autonomous Systems-The Direct Method of Lyapunov and the Linear Continuous-Time Autonomous Systems-Finding Lyapunov Functions for Nonlinear Continuous Time Autonomous Systems-Krasovskii and Variable-Gradiant Method.

UNIT V MODAL CONTROL 9

Introduction-Controllable and Observable Companion Forms-SISO and MIMO Systems – The Effect of State Feedback on Controllability and Observability-Pole Placement by State Feedback for both SISO and MIMO Systems-Full Order and Reduced Order Observers.

TOTAL : 45 PERIODS

COURSE OUTCOMES

CO1:To understand the concept of State-State equation for Dynamic Systems and the uniqueness of state model.
CO2:To understand the concept of the uniqueness of state model.
CO3:Analyse Controllability and Observability for Time varying and Time invariant case
CO4:Analyse the linear systems in state space
CO5:Design controllers in state space

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓								
CO2	✓	✓	✓	✓								
CO3	✓	✓	✓	✓								
CO4	✓	✓	✓	✓								
CO5	✓	✓	✓	✓								

REFERENCES:

1. M. Gopal, “Modern Control System Theory”, New Age International, 2005.
2. K. Ogatta, “Modern Control Engineering”, PHI, 2002.
3. John S. Bay, “Fundamentals of Linear State Space Systems”, McGraw-Hill, 1999.
4. D. Roy Choudhury, “Modern Control Systems”, New Age International, 2005.
5. John J. D’Azzo, C. H. Houpis and S. N. Sheldon, “Linear Control System Analysis and Design with MATLAB”, Taylor Francis, 2003.
6. Z. Bubnicki, ”Modern Control Theory”, Springer, 2005.

CO5074 SYSTEM IDENTIFICATION AND ADAPTIVE CONTROL LT P C
3 0 0 3

COURSE OBJECTIVES

- To introduce various model structures for system identification.
- To impart knowledge on parametric and non-parametric identification
- To introduce non-linear identification techniques.
- To introduce the concept of adaptation techniques and control.
- To illustrate the identification and adaptive control techniques through case studies.

UNIT I MODELS FOR INDENTIFICATION 9

Models of LTI systems: Linear Models-State space Models-OE model- Model sets, Structures and Identifiability-Models for Time-varying and Non-linear systems: Models with Nonlinearities – Non-linear state-space models-Black box models, Fuzzy models'.

UNIT II NON-PARAMETRIC AND PARAMETRIC IDENTIFICATON 9

Transient response and Correlation Analysis – Frequency response analysis – Spectral Analysis – Least Square – Recursive Least Square –Forgetting factor- Maximum Likelihood – Instrumental Variable methods.

UNIT III NON-LINEAR IDENTIFICATION 9

Open and closed loop identification: Approaches – Direct and indirect identification – Joint input-output identification – Non-linear system identification – Wiener models – Power series expansions - State estimation techniques – Non linear identification using Neural Network and Fuzzy Logic.

UNIT IV ADAPTIVE COTROL AND ADAPTATION TECHNIQUES 9

Introduction – Uses – Auto tuning – Self Tuning Regulators (STR) – Model Reference Adaptive Control (MRAC) – Types of STR and MRAC – Different approaches to self-tuning regulators – Stochastic Adaptive control – Gain Scheduling.

UNIT V CASE STUDIES 9

Inverted Pendulum, Robot arm, process control application: heat exchanger, Distillation column, application to power system, Ship steering control.

TOTAL : 45 PERIODS

COURSE OUTCOMES

Ability to

CO1:model LTI system and to analyse the Non-linear state-space model of a black box.
CO2:analyse frequency, spectral, correlation and transient response of a system.
CO3:Identify the Open & closed Loop of a Non-linear system by Neural network and Fuzzy Logic controller.
CO4:Realize different tuning parameters for adaptive control and adaptive technique.
CO5:Apply different control techniques to various applications

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓									
CO2	✓	✓	✓									
CO3	✓	✓	✓	✓	✓							
CO4	✓	✓	✓	✓	✓							
CO5		✓	✓	✓	✓							

Attested

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1. Ljung," System Identification Theory for the User", PHI, 1987.

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2. Torsten Soderstrom, Petre Stoica, “System Identification”, prentice Hall ‘International (UK) Ltd,1989.
3. Astrom and Wittenmark,” Adaptive Control ”, PHI
4. William S. Levine, “ Control Hand Book”.
5. Narendra and Annasamy,” Stable Adaptive Control Systems, Prentice Hall, 1989.

HV5151 ELECTROMAGNETIC FIELD COMPUTATION AND MODELLING **L T P C 3 0 0 3**

COURSE OBJECTIVES:

- To refresh the fundamentals of Electromagnetic Field Theory
- To provide foundation in formulation and computation of Electromagnetic Fields using analytical and numerical methods.
- To impart knowledge in fundamentals of FEM
- To compute and analyze the field quantities using FEM
- To formulate, solve, analyze and optimize the design of electrical components

UNIT I INTRODUCTION 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 II 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.

UNIT III 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 IV 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 V DESIGN APPLICATIONS 9

Design of Insulators –Magnetic actuators – Transformers – Rotating machines.

L=45: T=0, TOTAL = 45 PERIODS

COURSE OUTCOMES:

CO1 Ability to understand the field theory concepts
CO2 Ability to formulate and compute Electromagnetic Fields from Maxwell’s equations.
CO3 Ability to formulate FEM problems from the fundamental concepts
CO4 Ability to compute the respective field using FEM (post processing)
CO5 Ability to check and optimize the design of electrical power equipment

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2		✓										
CO3			✓		✓							
CO4					✓							
CO5			✓		✓							

Attested

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REFERENCES

1. Matthew. N.O. Sadiku, S.V. Kulkarni, “Elements of Electromagnetics”, Sixth Edition, Oxford University Press, Asian Edition 2015.
2. K.J.Binns, P.J.Lawrenson, C.W Trowbridge, “The analytical and numerical solution of Electric and magnetic fields”, John Wiley & Sons, 1993.
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5. S.J Salon, “Finite Element Analysis of Electrical Machines” Kluwer Academic Publishers, London, 1995, distributed by TBH Publishers & Distributors, Chennai, India.
6. Silvester and Ferrari, “Finite Elements for Electrical Engineers” Cambridge University press, 1983

ET5071 ADVANCED DIGITAL SIGNAL PROCESSING LT P C
3 0 0 3

COURSE OBJECTIVES:

- To expose the fundamentals of digital signal processing in frequency domain& its application
- To teach the fundamentals of digital signal processing in time-frequency domain& its application
- To teach the fundamentals of audio signal processing & its application
- To discuss on Application development with commercial family of DS Processors
- To involve Discussions/ Practice/Exercise onto revising & familiarizing the concepts acquired over the 5 Units of the subject for improved employability skills

UNIT I INTRODUCTION TO DIGITAL SIGNAL PROCESSING 6

Introduction to Digital Signal Processing System- Discrete Time Sequences- Time-Invariant & Time-variant Systems, Decimation and Interpolation- The Sampling Process - Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT)- Basics of Digital Filters- FIR Filters, IIR Filters -adaptive filter based on LMS.

UNIT II WAVELET TRANSFORM 9

Introduction to continuous wavelet transform- discrete wavelet transform -orthogonal wavelet decomposition- Multiresolution Analysis-Wavelet function-DWT,bases,orthogonal Basis-Scaling function, Wavelet coefficients- Multirate signal processing and their relationship to filter banks-Digital filtering interpolation(i) Decomposition filters, (ii) reconstruction, the signal- Example MRA-Haar & Daubechies wavelet.

UNIT III AUDIO SIGNAL PROCESSING 12

Introduction to Speech and Audio Processing - Speech Signal Processing- Pitch-period estimation, all-pole and all-zero filters- convolution - autoregressive model, autocorrelation estimation, General structure of speech coders; Requirements of speech codecs –quality, LPC model of speech production- LPC encoders and decoders-Power spectral density, periodogram ,Spectral measures of audio signal.

UNIT IV ARCHITECTURES OF COMMERCIAL DIGITAL SIGNAL PROCESSORS 12

Introduction, catogorisation of DSP Processors-one case example Architecture Processor for Fixed Point (Blackfin),Floating Point & Speech Processor- Basics of Architecture – study of functional variations of Computational building blocks(with comparison onto their MAC, Bus Architecture ,I/O interface,application).

Approved

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UNIT V IMPLEMENTATION OF DSP BASED SYSTEMS 6

Introduction- Interfacing processor- Memory Interface-I/O Interface-Mapping of DSP algorithm onto hardware -Design of Filter-FFT Algorithm- Application with DSP based Interfacing- Power Meter; DSP as motor control

NOTE: Discussions/Miniproject/Practice on Workbench : Signal analysis transforms,Filter design concepts with simulation tools as Matlab /Labview/ VLSI/CCS/other suites to understand the commercial DSP processor technology and practice in programming.

.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: The concepts of Time and frequency analysis of Signal Transforms based on signal types.
CO2: The fundamentals of Time-Frequency Transforms are introduced
CO3: Analyze the quality and properties of speech based on DSP
CO4: Study features through comparison on commercial available DSProcessors
CO5: Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in signal processing for embedded systems design.

	O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	O11	O12
O1	✓	✓	✓	✓	✓							
O2		✓	✓									
O3		✓	✓									
O4		✓	✓									
O5		✓			✓							

REFERENCES:

1. John G. Proaks, Dimitris G. Manolakis, “Digital Signal Processing”, Pearson Education 2002.
2. Vinay K.Ingle,John G.Proakis,”DSP-A Matlab Based Approach”,Cengage Learning,2010
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OPEN ELECTIVE COURSES (OEC)

OE5091 BUSINESS DATA ANALYTICS L T P C
3 0 0 3

OBJECTIVES:

- To understand the basics of business analytics and its life cycle.
- To gain knowledge about fundamental business analytics.
- To learn modeling for uncertainty and statistical inference.
- To understand analytics using Hadoop and Map Reduce frameworks.
- To acquire insight on other analytical frameworks.

UNIT I OVERVIEW OF BUSINESS ANALYTICS 9

Introduction – Drivers for Business Analytics – Applications of Business Analytics: Marketing and Sales, Human Resource, Healthcare, Product Design, Service Design, Customer Service and Support – Skills Required for a Business Analyst – Framework for Business Analytics Life Cycle for Business Analytics Process.

Suggested Activities:

- Case studies on applications involving business analytics.
- Converting real time decision making problems into hypothesis.
- Group discussion on entrepreneurial opportunities in Business Analytics.

Suggested Evaluation Methods:

- Assignment on business scenario and business analytical life cycle process.
- Group presentation on big data applications with societal need.
- Quiz on case studies.

UNIT II ESSENTIALS OF BUSINESS ANALYTICS 9

Descriptive Statistics – Using Data – Types of Data – Data Distribution Metrics: Frequency, Mean, Median, Mode, Range, Variance, Standard Deviation, Percentile, Quartile, z-Score, Covariance, Correlation – Data Visualization: Tables, Charts, Line Charts, Bar and Column Chart, Bubble Chart, Heat Map – Data Dashboards.

Suggested Activities:

- Solve numerical problems on basic statistics.
- Explore chart wizard in MS Excel Case using sample real time data for data visualization.
- Use R tool for data visualization.

Suggested Evaluation Methods:

- Assignment on descriptive analytics using benchmark data.
- Quiz on data visualization for univariate, bivariate data.

UNIT III MODELING UNCERTAINTY AND STATISTICAL INFERENCE 9

Modeling Uncertainty: Events and Probabilities – Conditional Probability – Random Variables – Discrete Probability Distributions – Continuous Probability Distribution – Statistical Inference: Data Sampling – Selecting a Sample – Point Estimation – Sampling Distributions – Interval Estimation – Hypothesis Testing.

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Suggested Activities:

- Solving numerical problems in sampling, probability, probability distributions and hypothesis testing.
- Converting real time decision making problems into hypothesis.

Suggested Evaluation Methods:

- Assignments on hypothesis testing.
- Group presentation on real time applications involving data sampling and hypothesis testing.
- Quizzes on topics like sampling and probability.

UNIT IV ANALYTICS USING HADOOP AND MAPREDUCE FRAMEWORK 9

Introducing Hadoop– RDBMS versus Hadoop–Hadoop Overview – HDFS (Hadoop Distributed File System) – Processing Data with Hadoop– Introduction to MapReduce – Features of MapReduce – Algorithms Using Map-Reduce: Matrix-Vector Multiplication, Relational Algebra Operations, Grouping and Aggregation – Extensions to MapReduce.

Suggested Activities:

- Practical – Install and configure Hadoop.
- Practical – Use web based tools to monitor Hadoop setup.
- Practical – Design and develop MapReduce tasks for word count, searching involving text corpus etc.

Suggested Evaluation Methods:

- Evaluation of the practical implementations.
- Quizzes on topics like HDFS and extensions to MapReduce.

UNIT V OTHER DATA ANALYTICAL FRAMEWORKS 9

Overview of Application development Languages for Hadoop – PigLatin – Hive – Hive Query Language (HQL) – Introduction to Pentaho, JAQL – Introduction to Apache: Sqoop, Drill and Spark, Cloudera Impala – Introduction to NoSQL Databases – Hbase and MongoDB.

Suggested Activities:

- Practical – Installation of NoSQL database like MongoDB.
- Practical – Demonstration on Sharding in MongoDB.
- Practical – Install and run Pig
- Practical – Write PigLatin scripts to sort, group, join, project, and filter data.
- Design and develop algorithms to be executed in MapReduce involving numerical methods for analytics.

Suggested Evaluation Methods:

- Mini Project (Group) – Real time data collection, saving in NoSQL, implement analytical techniques using Map-Reduce Tasks and Result Projection.

TOTAL: 45 PERIODS

OUTCOMES:

On completion of the course, the student will be able to:

- Identify the real world business problems and model with analytical solutions.
- Solve analytical problem with relevant mathematics background knowledge.
- Convert any real world decision making problem to hypothesis and apply suitable statistical testing.
- Write and Demonstrate simple applications involving analytics using Hadoop and MapReduce
- Use open source frameworks for modeling and storing data.
- Apply suitable visualization technique using R for visualizing voluminous data.

Attested

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REFERENCES:

1. VigneshPrajapati, “Big Data Analytics with R and Hadoop”, Packt Publishing, 2013.
2. Umesh R Hodeghatta, UmeshaNayak, “Business Analytics Using R – A Practical Approach”, Apress, 2017.
3. AnandRajaraman, Jeffrey David Ullman, “Mining of Massive Datasets”, Cambridge University Press, 2012.
4. Jeffrey D. Camm, James J. Cochran, Michael J. Fry, Jeffrey W. Ohlmann, David R. Anderson, “Essentials of Business Analytics”, Cengage Learning, second Edition, 2016.
5. U. Dinesh Kumar, “Business Analytics: The Science of Data-Driven Decision Making”, Wiley, 2017.
6. A. Ohri, “R for Business Analytics”, Springer, 2012
7. Rui Miguel Forte, “Mastering Predictive Analytics with R”, Packt Publication, 2015.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	2	3	1
CO2	2	1	1	2	1	1
CO3	1	1	2	3	3	1
CO4	2	2	1	2	1	1
CO5	1	1	2	2	1	1
CO6	1	1	1	3	2	1

OE5092 **INDUSTRIAL SAFETY** **LT P C**
3 0 0 3

OBJECTIVES:

- Summarize basics of industrial safety
- Describe fundamentals of maintenance engineering
- Explain wear and corrosion
- Illustrate fault tracing
- Identify preventive and periodic maintenance

UNIT I INTRODUCTION **9**

Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

UNIT II FUNDAMENTALS OF MAINTENANCE ENGINEERING **9**

Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

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UNIT III WEAR AND CORROSION AND THEIR PREVENTION 9

Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

UNIT IV FAULT TRACING 9

Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

UNIT V PERIODIC AND PREVENTIVE MAINTENANCE 9

Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

TOTAL: 45 PERIODS

OUTCOMES:

CO1: Ability to summarize basics of industrial safety
CO2: Ability to describe fundamentals of maintenance engineering
CO3: Ability to explain wear and corrosion
CO4: Ability to illustrate fault tracing
CO5: Ability to identify preventive and periodic maintenance

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES:

1. Audels, Pump-hydraulic Compressors, Mcgrew Hill Publication, 1978.
2. Garg H P,Maintenance Engineering, S. Chand and Company,1987.
3. Hans F. Winterkorn ,Foundation Engineering Handbook, Chapman & Hall London,2013.
4. Higgins & Morrow , Maintenance Engineering Handbook, Eighth Edition,2008

OE5093 OPERATIONS RESEARCH LT P C
3 0 0 3

OBJECTIVES:

- Solve linear programming problem and solve using graphical method.
- Solve LPP using simplex method
- Solve transportation , assignment problems
- Solve project management problems
- Solve scheduling problems

UNIT I LINEAR PROGRAMMING 9

Introduction to Operations Research – assumptions of linear programming problems - Formulations of linear programming problem – Graphical method

UNIT II ADVANCES IN LINEAR PROGRAMMING 9

Solutions to LPP using simplex algorithm- Revised simplex method - primal dual relationships – Dual simplex algorithm - Sensitivity analysis

UNIT III NETWORK ANALYSIS – I 9

Transportation problems -Northwest corner rule, least cost method,Voges's approximation method - Assignment problem -Hungarian algorithm

UNIT IV NETWORK ANALYSIS – II 9

Shortest path problem: Dijkstra's algorithms, Floyds algorithm, systematic method -CPM/PERT

UNIT V NETWORK ANALYSIS – III 9

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models

TOTAL: 45 PERIODS

OUTCOMES:

CO1: To formulate linear programming problem and solve using graphical method.
CO2: To solve LPP using simplex method
CO3: To formulate and solve transportation, assignment problems
CO4: To solve project management problems
CO5: To solve scheduling problems

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES:

1. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010
2. Hitler Libermann, Operations Research: McGraw Hill Pub. 2009
3. Pant J C, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Pannerselvam, Operations Research: Prentice Hall of India 2010
5. Taha H A, Operations Research, An Introduction, PHI, 2008

OE5094 COST MANAGEMENTOF ENGINEERING PROJECTS L T P C
3 0 0 3

OBJECTIVES:

- Summarize the costing concepts and their role in decision making
- Infer the project management concepts and their various aspects in selection
- Interpret costing concepts with project execution
- Develop knowledge of costing techniques in service sector and various budgetary control techniques
- Illustrate with quantitative techniques in cost management

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UNIT I INTRODUCTION TO COSTING *CONCEPTS* 9

Objectives of a Costing System; Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost; Creation of a Database for operational control.

UNIT II INTRODUCTION TO PROJECT MANAGEMENT 9

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities, Detailed Engineering activities, Pre project execution main clearances and documents, Project team: Role of each member,Importance Project site: Data required with significance, Project contracts.

UNIT III PROJECT EXECUTION AND COSTING CONCEPTS 9

Project execution Project cost control, Bar charts and Network diagram, Project commissioning: mechanical and process, Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis, Various decision-making problems, Pricing strategies: Pareto Analysis, Target costing, Life Cycle Costing.

UNIT IV COSTING OF SERVICE SECTOR AND BUDGETERY CONTROL 9

Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis, Budgetary Control: Flexible Budgets; Performance budgets; Zero-based budgets.

UNIT V QUANTITATIVE TECHNIQUES FOR COST MANAGEMENT 9

Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Learning Curve Theory.

TOTAL: 45 PERIODS

OUTCOMES

CO1 – Understand the costing concepts and their role in decision making
CO2–Understand the project management concepts and their various aspects in selection
CO3–Interpret costing concepts with project execution
CO4–Gain knowledge of costing techniques in service sector and various budgetary control techniques
CO5 - Become familiar with quantitative techniques in cost management

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓		✓			✓	✓		✓	✓
CO2	✓	✓	✓		✓				✓		✓	✓
CO3	✓	✓	✓		✓	✓					✓	✓
CO4	✓	✓	✓		✓		✓				✓	✓
CO5	✓	✓	✓		✓	✓	✓				✓	✓

REFERENCES:

1. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher, 1991
2. Charles T. Horngren and George Foster, Advanced Management Accounting, 1988
3. Charles T. Horngren et al Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi, 2011
4. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting, 2003
5. Vohra N.D., Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd, 2007

OE5095 **COMPOSITE MATERIALS** **L T P C**
3 0 0 3

OBJECTIVES:

- Summarize the characteristics of composite materials and effect of reinforcement in composite materials.
- Identify the various reinforcements used in composite materials.
- Compare the manufacturing process of metal matrix composites.
- Understand the manufacturing processes of polymer matrix composites.
- Analyze the strength of composite materials.

UNIT I INTRODUCTION **9**

Definition – Classification and characteristics of Composite materials - Advantages and application of composites - Functional requirements of reinforcement and matrix - Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

UNIT II REINFORCEMENTS **9**

Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers - Properties and applications of whiskers, particle reinforcements - Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures - Isostrain and Isostress conditions.

UNIT III MANUFACTURING OF METAL MATRIX COMPOSITES **9**

Casting – Solid State diffusion technique - Cladding – Hot isostatic pressing - Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving - Properties and applications.

UNIT IV MANUFACTURING OF POLYMER MATRIX COMPOSITES **9**

Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding - Properties and applications.

UNIT V STRENGTH **9**

Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

TOTAL: 45 PERIODS

OUTCOMES:

- CO1 - Know the characteristics of composite materials and effect of reinforcement in composite materials.
- CO2 – Know the various reinforcements used in composite materials.
- CO3 – Understand the manufacturing processes of metal matrix composites.
- CO4 – Understand the manufacturing processes of polymer matrix composites.
- CO5 – Analyze the strength of composite materials.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		✓	✓	✓								
CO2		✓	✓	✓	✓						✓	
CO3			✓	✓	✓		✓					
CO4			✓	✓	✓		✓					
CO5				✓	✓		✓					

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REFERENCES:

1. Cahn R.W. - Material Science and Technology – Vol 13 – Composites, VCH, WestGermany.
2. Callister, W.D Jr., Adapted by Balasubramaniam R, Materials Science and Engineering, An introduction, John Wiley & Sons, NY, Indian edition, 2007.
3. Chawla K.K., Composite Materials, 2013.
4. Lubin.G, Hand Book of Composite Materials, 2013.

OE5096 WASTE TO ENERGY L T P C
3 0 0 3

OBJECTIVES:

- Interpret the various types of wastes from which energy can be generated
- Develop knowledge on biomass pyrolysis process and its applications
- Develop knowledge on various types of biomass gasifiers and their operations
- Invent knowledge on biomass combustors and its applications on generating energy
- Summarize the principles of bio-energy systems and their features

UNIT I INTRODUCTION TO EXTRACTION OF ENERGY FROM WASTE 9

Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

UNIT II BIOMASS PYROLYSIS 9

Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

UNIT III BIOMASS GASIFICATION 9

Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

UNIT IV BIOMASS COMBUSTION 9

Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

UNIT V BIO ENERGY 9

Properties of biogas (Calorific value and composition), Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production -Urban waste to energy conversion - Biomass energy programme in India.

TOTAL: 45 PERIODS

OUTCOMES:

CO1 – Understand the various types of wastes from which energy can be generated
CO2 – Gain knowledge on biomass pyrolysis process and its applications
CO3 – Develop knowledge on various types of biomass gasifiers and their operations
CO4 – Gain knowledge on biomass combustors and its applications on generating energy
CO5 – Understand the principles of bio-energy systems and their features

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓		✓									✓
CO2	✓		✓									✓
CO3	✓	✓	✓		✓							✓
CO4	✓	✓	✓		✓		✓					✓
CO5	✓	✓	✓		✓							✓

REFERENCES:

1. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
2. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.

AUDIT COURSES (AC)

AX5091 ENGLISH FOR RESEARCH PAPER WRITING **L T P C**
2 0 0 0

OBJECTIVES

- Teach how to improve writing skills and level of readability
- Tell about what to write in each section
- Summarize the skills needed when writing a Title
- Infer the skills needed when writing the Conclusion
- Ensure the quality of paper at very first-time submission

UNIT I INTRODUCTION TO RESEARCH PAPER WRITING **6**

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

UNIT II PRESENTATION SKILLS **6**

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction

UNIT III TITLE WRITING SKILLS **6**

Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check

UNIT IV RESULT WRITING SKILLS **6**

Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions

UNIT V VERIFICATION SKILLS **6**

Useful phrases, checking Plagiarism, how to ensure paper is as good as it could possibly be the first- time submission

TOTAL: 30 PERIODS

OUTCOMES

CO1 –Understand that how to improve your writing skills and level of readability
CO2 – Learn about what to write in each section
CO3 – Understand the skills needed when writing a Title
CO4 – Understand the skills needed when writing the Conclusion

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CO5 – Ensure the good quality of paper at very first-time submission

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										✓		✓
CO2										✓		✓
CO3										✓		✓
CO4										✓		✓
CO5										✓		✓

REFERENCES

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

AX5092 DISASTER MANAGEMENT L T P C
2 0 0 0

OBJECTIVES

- Summarize basics of disaster
- Explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- Describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
- Develop the strengths and weaknesses of disaster management approaches

UNIT I INTRODUCTION 6

Disaster: Definition, Factors and Significance; Difference between Hazard And Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.

UNIT II REPERCUSSIONS OF DISASTERS AND HAZARDS 6

Economic Damage, Loss of Human and Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.

UNIT III DISASTER PRONE AREAS IN INDIA 6

Study of Seismic Zones; Areas Prone To Floods and Droughts, Landslides And Avalanches; Areas Prone To Cyclonic and Coastal Hazards with Special Reference To Tsunami; Post-Disaster Diseases and Epidemics

UNIT IV DISASTER PREPAREDNESS AND MANAGEMENT 6

Preparedness: Monitoring Of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological And Other Agencies, Media Reports: Governmental and Community Preparedness.

UNIT V RISK ASSESSMENT 6

Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival

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TOTAL : 30 PERIODS

OUTCOMES

CO1: Ability to summarize basics of disaster
CO2: Ability to explaina critical understanding of key concepts in disaster riskreduction and humanitarian response.
CO3: Ability to illustratedisaster risk reduction and humanitarian response policy and practice from multiple perspectives.
CO4: Ability to describean understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
CO5: Ability to develop the strengths and weaknesses of disaster management approaches

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES

1. Goel S. L., Disaster Administration And Management Text And Case Studies",Deep & Deep Publication Pvt. Ltd., New Delhi,2009.
2. NishithaRai, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'NewRoyal book Company,2007.
3. Sahni, PardeepEt.Al. ," Disaster Mitigation Experiences And Reflections", Prentice Hall OfIndia, New Delhi,2001.

AX5093 SANSKRIT FOR TECNICAL KNOWLEDGE L T P C
2 0 0 0

OBJECTIVES

- Illustrate the basic sanskrit language.
- Recognize sanskrit, the scientific language in the world.
- Appraise learning of sanskrit to improve brain functioning.
- Relate sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power.
- Extract huge knowledge from ancient literature.

UNIT I ALPHABETS **6**

Alphabets in Sanskrit

UNIT II TENSES AND SENTENCES **6**

Past/Present/Future Tense - Simple Sentences

UNIT III ORDER AND ROOTS **6**

Order - Introduction of roots

UNIT IV SANSKRIT LITERATURE **6**

Technical information about Sanskrit Literature

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UNIT V TECHNICAL CONCEPTS OF ENGINEERING 6

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

TOTAL: 30 PERIODS

OUTCOMES

- CO1 - Understanding basic Sanskrit language.
- CO2 - Write sentences.
- CO3 - Know the order and roots of Sanskrit.
- CO4 - Know about technical information about Sanskrit literature.
- CO5 - Understand the technical concepts of Engineering.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										✓		✓
CO2										✓		✓
CO3												✓
CO4												✓
CO5												✓

REFERENCES

1. "Abhyaspustakam" – Dr. Vishwas, Samskrita-Bharti Publication, New Delhi
2. "Teach Yourself Sanskrit" Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. "India's Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi, 2017.

AX5094 VALUE EDUCATION L T P C
2 0 0 0

OBJECTIVES

Students will be able to

- Understand value of education and self-development
- Imbibe good values in students
- Let the should know about the importance of character

UNIT I

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

UNIT II

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

UNIT III

Personality and Behavior Development-Soul and Scientific attitude. Positive Thinking. Integrity and discipline. Punctuality, Love and Kindness. Avoid fault Thinking. Free from anger, Dignity of labour.

Universal brother hood and religious tolerance. True friendship. Happiness Vs suffering, love for truth. Aware of self-destructive habits. Association and Cooperation. Doing best for saving nature

UNIT IV

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

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TOTAL: 30 PERIODS

OUTCOMES

Students will be able to

- Knowledge of self-development.
- Learn the importance of Human values.
- Developing the overall personality.

Suggested reading

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

AX5095 **CONSTITUTION OF INDIA** **L T P C**
2 0 0 0

OBJECTIVES

Students will be able to:

- Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
- To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional
- Role and entitlement to civil and economic rights as well as the emergence nation hood in the early years of Indian nationalism.
- To address the role of socialism in India after the commencement of the Bolshevik Revolutionin1917and its impact on the initial drafting of the Indian Constitution.

UNIT I HISTORY OF MAKING OF THE INDIAN CONSTITUTION:

History, Drafting Committee, (Composition & Working)

UNIT II PHILOSOPHY OF THE INDIAN CONSTITUTION:

Preamble, Salient Features

UNIT III CONTOURS OF CONSTITUTIONAL RIGHTS AND DUTIES:

Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

UNIT IV ORGANS OF GOVERNANCE:

Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions.

UNIT V LOCAL ADMINISTRATION:

District's Administration head: Role and Importance, • Municipalities: Introduction, Mayor and role of Elected Representative, CEO, Municipal Corporation. Pachayati raj: Introduction, PRI: Zila Pachayat. Elected officials and their roles, CEO Zila Pachayat: Position and role. Block level: Organizational Hierarchy(Different departments), Village level:Role of Elected and Appointed officials, Importance of grass root democracy.

UNIT VI ELECTION COMMISSION:

Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners - Institute and Bodies for the welfare of SC/ST/OBC and women.

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to:

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

Suggested reading

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

AX5096 **PEDAGOGY STUDIES** **L T P C**
2 0 0 0

OBJECTIVES

Students will be able to:

- Review existing evidence on there view topic to inform programme design and policy
- Making under taken by the DfID, other agencies and researchers.
- Identify critical evidence gaps to guide the development.

UNIT I INTRODUCTION AND METHODOLOGY:

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

UNIT II THEMATIC OVERVIEW

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

UNIT III EVIDENCE ON THE EFFECTIVENESS OF PEDAGOGICAL PRACTICES

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

UNIT IV PROFESSIONAL DEVELOPMENT

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

UNIT V RESEARCH GAPS AND FUTURE DIRECTIONS

Research design – Contexts – Pedagogy - Teacher education - Curriculum and assessment - Dissemination and research impact.

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to understand:

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

Suggested reading

1. Ackers J, HardmanF (2001) Classroom interaction in Kenyan primary schools, Compare, 31(2): 245-261.
2. Agrawal M (2004)Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36(3):361-379.
3. Akyeampong K (2003) Teacher training in Ghana-does it count? Multi-site teacher education research project (MUSTER) country report 1 London:DFID.

4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33(3): 272–282.
5. Alexander RJ(2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. Chavan M(2003) Read India: Amass scale, rapid, 'learning to read' campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.

AX5097 **STRESS MANAGEMENT BY YOGA** **L T P C**
2 0 0 0

OBJECTIVES
- To achieve overall health of body and mind
- To overcome stress

UNIT I
Definitions of Eight parts of yoga.(Ashtanga)

UNIT II
Yam and Niyam - Do's and Don't's in life - i) Ahinsa, satya, astheya, bramhacharya and aparigraha, ii) Ahinsa, satya, astheya, bramhacharya and aparigraha.

UNIT III
Asan and Pranayam - Various yog poses and their benefits for mind & body - Regularization of breathing techniques and its effects-Types of pranayam

TOTAL: 30 PERIODS

OUTCOMES
Students will be able to:
- Develop healthy mind in a healthy body thus improving social health also
- Improve efficiency

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

AX5098 **PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS** **L T P C**
2 0 0 0

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

UNIT I
Neetisatakam-holistic development of personality - Verses- 19,20,21,22 (wisdom) - Verses- 29,31,32 (pride & heroism) – Verses- 26,28,63,65 (virtue) - Verses- 52,53,59 (dont's) - Verses- 71,73,75,78 (do's)

UNIT II

Approach to day to day work and duties - Shrimad Bhagwad Geeta: Chapter 2-Verses 41, 47,48 - Chapter 3-Verses 13, 21, 27, 35 Chapter 6-Verses 5,13,17,23, 35 - Chapter 18-Verses 45, 46, 48.

UNIT III

Statements of basic knowledge - Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68 Chapter 12 -Verses 13, 14, 15, 16,17, 18 - Personality of role model - shrimad bhagwad geeta - Chapter2-Verses 17, Chapter 3-Verses 36,37,42 - Chapter 4-Verses 18, 38,39 Chapter18 – Verses 37,38,63

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to

- Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
- The person who has studied Geeta will lead the nation and man kind to peace and prosperity
- Study of Neet is hatakam will help in developing versatile personality of students.

Suggested reading

1. Gopinath, Rashtriya Sanskrit Sansthanam P, Bhartrihari's Three Satakam, Niti-sringar-vairagya, New Delhi,2010
2. Swami Swarupananda , Srimad Bhagavad Gita, Advaita Ashram, Publication Department, Kolkata, 2016.