ANNA UNIVERSITY: CHENNAI 600 025
NON AUTONOMOUS COLLEGES AFFILIATED TO ANNA UNIVERSITY
REGULATIONS – 2021
CHOICE BASED CREDIT SYSTEM
M.E. POWER ELECTRONICS AND DRIVES (FULL TIME)

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs) :

i. To prepare the students for successful career in power electronic industry, research and teaching institutions.
ii. To analyze, design and develop the power electronic converter/drive systems.
iii. To develop the ability to analyze the dynamics in power electronic converters/drives systems and design various controllers to meet the performance criteria.
iv. To design power electronic systems and special electrical machines for efficient extraction and utilization of various renewable energy sources.
v. To promote student awareness for the lifelong learning and to introduce them to professional ethics.

PO#	Programme Outcomes
1	An ability to independently carry out research/investigation and development work to solve practical problems
2	An ability to write and present a substantial technical report/document.
3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
4	Apply knowledge of basic science and engineering in design and testing of power electronic systems and drives.
5	Interact with Industry in a professional and ethical manner to meet the requirements of societal needs and to contribute sustainable development of the society.
6	Implement cost effective and cutting edge technologies in power electronics and drives system.

PEO/PO Mapping:

PEO	PO					
	1	**2**	**3**	**4**	**5**	**6**
I.	3	3	3	2	2	1
II.	2	2	2	3	1	2
III.	3	1	1	2	2	3
IV.	3	1	2	3	3	2
V.	2	1	1	1	3	1

1,2,3,-, scale against the correlation PO's with PEO's

PROGRAM ARTICULATION MATRIX OF PG - POWER ELECTRONICS AND DRIVES ENGINEERING

		COURSE NAME	PO1	PO2	PO3	PO4	PO5	PO6
YEAR I	SEMESTER I	Applied Mathematics For Power Electronics Engineers						
		Analysis of Electrical Machines	3	3	3	3	3	3
		Analysis of Power Converters	3	0	3	3	2	2
		Modeling and Design of SMPS	2	0	2	2.2	1.8	1.8
		Research Methodology and IPR						
		Professional Elective – I						
		Audit Course I*						
		Power Converters Laboratory	2	1	3	1	2	3
		Analog and Digital Controllers for PE Converters Laboratory	2	1	1.4	1	1.8	2
	SEMESTER II	Analysis of Electrical Drives	1.6	1	2	3	1	1.6
		Special Electrical Machines	3	1	3	2	2	2
		Electric Vehicles and Power Management	3	3	3	2	3	2
		Professional Elective – II						
		Professional Elective – III						
		Audit Course II*						
		Power Electronics and Drives Laboratory	3	0	3	3	3	2
		Design Laboratory for Power Electronics Systems	3	0	3	3	3	3
YEAR II	SEMESTER III	Professional Elective – IV						
		Professional Elective – V						
		Open Elective						
		Project Work – I						
	SEMESTER IV	Project Work – II						

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

SEMESTER I

S.NO	COURSE CODE	COURSE TITLE	CATE-GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MA4106	Applied Mathematics for Power Electronics Engineers	FC	3	1	0	4	4
2.	PX4101	Analysis of Electrical Machines	PCC	3	1	0	4	4
3.	PX4151	Analysis of Power Converters	PCC	3	1	0	4	4
4.	PX4102	Modeling and Design of SMPS	PCC	3	0	0	3	3
5.	RM4151	Research Methodology and IPR	RMC	2	0	0	2	2
6.		Professional Elective I	PEC	3	0	0	3	3
7.		Audit Course I*	AC	2	0	0	2	0
PRACTICALS								
8.	PX4161	Power Converters Laboratory	PCC	0	0	3	3	1.5
9.	PX4111	Analog and Digital Controllers for PE Converters Laboratory	PCC	1	0	3	4	2.5
			TOTAL	**20**	**3**	**6**	**29**	**24**

*** 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.	PX4201	Analysis of Electrical Drives	PCC	3	1	0	4	4
2.	PX4202	Special Electrical Machines	PCC	3	0	0	3	3
3.	PX4291	Electric Vehicles and Power Management	PCC	3	1	0	4	4
4.		Professional Elective II	PEC	3	0	0	3	3
5.		Professional Elective III	PEC	3	0	0	3	3
6.		Audit course II*	AC	2	0	0	2	0
PRACTICALS								
7.	PX4211	Power Electronics and Drives Laboratory	PCC	0	0	3	3	1.5
8.	PX4212	Design Laboratory for Power Electronics Systems	PCC	0	0	3	3	1.5
			TOTAL	**17**	**2**	**6**	**25**	**20**

*** Audit Course is optional**

SEMESTER III

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.		Professional Elective IV	PEC	3	0	0	3	3
2.		Professional Elective V	PEC	3	0	0	3	3
3.		Open Elective	OEC	3	0	0	3	3
PRACTICALS								
4.	PX4311	Project Work I	EEC	0	0	12	12	6
			TOTAL	**9**	**0**	**12**	**21**	**15**

SEMESTER IV

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	PX4411	Project Work II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL NO. OF CREDITS: 71

FOUNDATION COURSES (FC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			LECTURE	TUTORIAL	PRACTICAL		
1.	MA4106	Applied Mathematics for Power Electronics Engineers	3	1	0	4	I

PROFESSIONAL CORE COURSES (PCC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			LECTURE	TUTORIAL	PRACTICAL		
1	PX4101	Analysis of Electrical Machines	3	1	0	4	I
2	PX4151	Analysis of Power Converters	3	1	0	4	I
3	PX4102	Modeling and Design of SMPS	3	0	0	3	I
4	PX4161	Power Converters Laboratory	0	0	3	1.5	I
5	PX4111	Analog and Digital Controllers for PE Converters Laboratory	1	0	3	2.5	I
6	PX4201	Analysis of Electrical Drives	3	1	0	4	II
7	PX4202	Special Electrical Machines	3	0	0	3	II
8	PX4291	Electric Vehicles and Power Management	3	1	0	4	II
9	PX4211	Power Electronics and Drives Laboratory	0	0	3	1.5	II
10	PX4212	Design Laboratory for Power Electronics Systems	1	0	3	1.5	II
					TOTAL CREDITS	**29**	

RESEARCH METHODOLOGY AND IPR COURSES (RMC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			LECTURE	TUTORIAL	PRACTICAL		
1.	RM4151	Research Methodology and IPR	2	0	0	2	I

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S.NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			LECTURE	TUTORIAL	PRACTICAL		
1.	PX4311	Project Work I	0	0	12	6	III
2.	PX4411	Project Work II	0	0	24	12	IV
					TOTAL CREDITS	**18**	

PROFESSIONAL ELECTIVES

SEMESTER I
ELECTIVE I

S. NO.	COURS ECODE	COURSE TITLE	CATE-GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1	PX4001	Power Semiconductor Devices	PEC	3	0	0	3	3
2	PX4002	System Design Using Microcontroller	PEC	3	0	0	3	3
3	PX4003	Electromagnetic Field Computation and Modelling	PEC	3	0	0	3	3
4	PX4004	Soft Computing Techniques	PEC	3	0	0	3	3
5	PS4151	System Theory	PEC	3	0	0	3	3

SEMESTER II
ELECTIVE II & III

S. NO.	COURS ECODE	COURSE TITLE	CATE-GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1	PX4005	Power Electronics for Renewable Energy Systems	PEC	3	0	0	3	3
2	PX4006	Modern Rectifiers and Resonant Converters	PEC	3	0	0	3	3
3	PX4007	Advanced Power Converters	PEC	3	0	0	3	3
4	PX4009	Control of Power Electronic Circuits	PEC	3	0	0	3	3
5	PS4072	Energy Storage Technologies	PEC	3	0	0	3	3
6	PX4071	Power Quality	PEC	3	0	0	3	3
7	ET4071	DSP Based System Design	PEC	3	0	0	3	3
8	ET4072	Machine Learning and Deep Learning	PEC	3	0	0	3	3
9	ET4251	IoT for Smart Systems	PEC	3	0	0	3	3
10	ET4018	MEMS Design: Sensors and Actuators	PEC	3	0	0	3	3

SEMESTER III
ELECTIVE IV & V

S. NO.	COURS ECODE	COURSE TITLE	CATE-GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1	PX4010	Nonlinear Dynamics for Power Electronics Circuits	PEC	3	0	0	3	3
2	PX4011	Grid Integration of Renewable Energy Sources	PEC	3	0	0	3	3
3	PX4012	Renewable Energy Technology	PEC	3	0	0	3	3
4	PX4013	Wind Energy Conversion System	PEC	3	0	0	3	3
5	PX4014	Optimization Techniques	PEC	3	0	0	3	3
6	PS4091	Distributed Generation and Micro Grid	PEC	3	0	0	3	3
7	PS4071	Energy Management and Auditing	PEC	3	0	0	3	3
8	PS4093	Smart Grid	PEC	3	0	0	3	3
9	PS4351	HVDC and FACTS	PEC	3	0	0	3	3
10	ET4073	Python Programming for Machine Learning	PEC	3	0	0	3	3

AUDIT COURSES - I

REGISTRATION FOR ANY OF THESE COURSES IS OPTIONAL TO STUDENTS

SL. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS
			L	T	P	
1.	AX4091	English for Research Paper Writing	2	0	0	0
2.	AX4092	Disaster Management	2	0	0	0
3.	AX4093	Constitution of India	2	0	0	0
4.	AX4094	நற்றமிழ்இலக்கியம்	2	0	0	0

SUMMARY

	Name of the Programme: M.E POWER ELECTRONICS AND DRIVES					
	SUBJECT AREA	CREDITS PER SEMESTER				CREDITS TOTAL
		I	II	III	IV	
1.	FC	4	0	0	0	4
2.	PCC	15	14	0	0	29
3.	PEC	3	6	6	0	15
4.	OEC	0	0	3	0	3
5.	EEC	0	0	6	12	18
6.	RMC	2	0	0	0	2
7.	Non Credit/Audit Course	√	√	0	0	0
	TOTAL	**24**	**20**	**15**	**12**	**71**

MA4106 APPLIED MATHEMATICS FOR POWER ELECTRONICS ENGINEERS **L T P C**
3 1 0 4

OBJECTIVES :

- To develop the ability to apply the concepts of matrix theory in Electrical Engineering problems.
- To familiarize the students in the field of differential equations to solve boundary value problems associated with engineering applications.
- To develop the ability among the students to solve problems using Laplace transform associated with engineering applications.
- To introduce the effective mathematical tools for the solutions of partial differential equations that model several physical processes and to develop Z transform techniques for discrete time systems.
- To develop the ability among the students to solve problems using Fourier series associated with engineering applications.

UNIT I MATRIX THEORY **12**

The Cholesky decomposition - Generalized Eigenvectors - Canonical basis - QR factorization - Singular value decomposition - Pseudo inverses - Least square approximation.

UNIT II CALCULUS OF VARIATIONS **12**

Concept of variations and its properties - Euler's theorem - Functional dependent on first and higher order of derivatives - Functionals dependent on functions of several independent variables - Variational problems with moving boundaries - Isoperimetric problems - Direct methods : Rayleigh Ritz method and Kantorovich problems .

UNIT III LAPLACE TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS **12**

Definitions - Properties - Transform error function - Bessel's function - Dirac Delta function -Unit step function - Convolution theorem - Inverse Laplace transform - Complex inversion formula - Solutions to partial differential equations : Heat and Wave equations.

UNIT IV Z - TRANSFORM TECNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS **12**

Z-transforms - Elementary properties – Convergence of Z-transforms - Initial and final value theorems - Inverse Z - transform (using partial fraction and residues) - Convolution theorem - Formation of difference equations – Solution of difference equations using Z - transforms.

UNIT V FOURIER SERIES **12**

Fourier Trigonometric series : Periodic function as power signals - Convergence of series - Even and odd functions : Cosine and sine series - Non periodic function - Extension to other intervals - Power signals : Exponential Fourier series - Parseval's theorem and power spectrum - Eigenvalue problems and orthogonal functions - Regular Sturm –Liouville systems - Generalized Fourier series.

TOTAL : 60 PERIODS

OUTCOMES :

- Able to apply the concepts of matrix theory in Electrical Engineering problems.
- Able to solve boundary value problems associated with engineering applications.
- Able to solve problems using Laplace transform associated with engineering applications.
- Use the effective mathematical tools for the solutions of partial differential equations by using Z transform techniques for discrete time systems.
- Able to solve problems using Fourier series associated with engineering applications.

MAPPING OF CO'S WITH PO'S

CO	PO					
	1	2	3	4	5	6
1	3	2	2	3	1	1
2	3	2	2	3	1	1
3	3	2	2	3	1	1
4	3	2	2	3	1	1
5	3	2	2	3	1	1
AVG	3	2	2	3	1	1

REFERENCES:

1. Richard Bronson, MATRIX OPERATION , Schaum's outline series, Second Edition, McGraw Hill, New Delhi , 2011.
2. Elsgolc. L.D., " CALCULUS OF VARIATIONS " , Dover Publications Inc., New York, 2007.
3. SankaraRao. K , INTRODUCTION TO PARTIAL DIFFERENTIAL EQUATIONS , Prentice Hall of India Pvt . Ltd, New Delhi , 1997.
4. Grewal.B.S., "Higher Engineering Mathematics", Khanna Publishers, New Delhi, 44th Edition , 2018.
5. Andrews .L.C, and Phillips. R.L, MATHEMATICAL TECHNIQUES FOR ENGINEERS AND SCIENTISTS , Prentice Hall , New Delhi , 2005.

PX4101	ANALYSIS OF ELECTRICAL MACHINES	L T P C
		3 1 0 4

OBJECTIVES:

- To understand the principles of electromechanical energy conversion in electrical machines and to know the dynamic characteristics of DC motors
- To study the concepts related with AC machines, magnetic noise and harmonics in rotating electrical machines.
- To interpret the principles of reference frame theory
- To study the principles of three phase, doubly fed and 'n' phase induction machine in machine variables and reference variables.
- To understand the principles of three phase, synchronous machine in machine variables and reference variables.

UNIT I ELECTROMECHANICAL ENERGY CONVERSION and DC MACHINES 12

Magnetic circuits, permanent magnet, Energy conservation - stored magnetic energy, co-energy - force and torque in singly and doubly excited systems – Elementary DC machine and analysis of steady state operation - Voltage and torque equations – dynamic characteristics - DC motors – Time domain block diagrams - solution of dynamic characteristic by Laplace transformation

UNIT II AC MACHINES -CONCEPTS 12

Distributed Windings - Winding Functions - Air-Gap Magnetomotive Force -Rotating MMF - Flux Linkage and Inductance -Resistance -Voltage and Flux Linkage Equations for Distributed Winding Machines--magnetic noise and harmonics in rotating electrical machines. Modeling of 'n' phase machine.

UNIT III REFERENCE FRAME THEORY 12

Historical background – phase transformation and commutator transformation – transformation of variables from stationary to arbitrary reference frame – transformation of balanced set-variables observed from several frames of reference.

UNIT IV INDUCTION MACHINES 12

Three phase induction machine and doubly fed 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- Transformation theory for ‘n’ phase induction machine.

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 –Krons primitive machine

TOTAL : 60 PERIODS

OUTCOMES:

After completion of this course, student will be able to

CO1: Understand the principles of electromechanical energy conversion and characteristics of DC motors

CO2: Know the concepts related with AC machines and modeling of ‘n’ phase machines

CO3: Interpret the concepts of reference frame theory.

CO4: Apply procedures to develop induction machine model in both machine variable form and reference variable forms

CO5: Follow the procedures to develop synchronous machine model in machine variables form and reference variable form.

REFERENCES:

1 Stephen D. Umans, “Fitzgerald & Kingsley’s Electric Machinery”, Tata McGraw Hill, 7th Edition, 2020.

2 Bogdan M. Wilamowski, J. David Irwin, The Industrial Electronics Handbook, Second Edition, Power Electronics and Motor Drives, CRC Press, 2011

3 Paul C. Krause, Oleg Wasynczuk, Scott D. Sudhoff, Steven D. Pekarek, “Analysis of Electric Machinery and Drive Systems”, 3rd Edition, Wiley-IEEE Press, 2013.

4 R. Krishnan, Electric Motor & Drives: Modeling, Analysis and Control, Pearson Education, 1st Imprint, 2015.

5 R.Ramanujam,Modeling and Analysis of Electrical Machines,I.k.International Publishing House Pvt.Ltd,2018

CO-PO MAPPING :

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

PX4151 ANALYSIS OF POWER CONVERTERS L T P C
3 1 0 4

OBJECTIVES:

- To provide the mathematical fundamentals necessary for deep understanding of power converter operating modes.
- To introduce the electrical circuit concepts behind the different working modes of power converters so as to enable deep understanding of their operation.
- To impart 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 inculcate knowledge to perform analysis 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 and its limit –Sequence control of converters – performance parameters – effect of source impedance and overlap-reactive power and power balance in converter circuit.

UNIT II THREE PHASE AC-DC CONVERTER 12

Half controlled and fully controlled converters 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 –Applications - Excitation system, DC drive system.

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 – Induction heating, AC 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

OUTCOMES:

After completing the above course, students will be able to

CO1 : Acquire and apply knowledge of mathematics in power converter analysis

CO2: Model, analyze and understand power electronic systems and equipments.

CO3 :Formulate, design and simulate phase controlled rectifiers for generic load and for machine loads

CO4 : Design and simulate switched mode inverters for generic load and for machine loads

CO5 : Select device and calculate performance parameters of power converters under various operating modes

REFERENCES:

1. Rashid M.H., "Power Electronics Circuits, Devices and Applications ", Pearson, fourth Edition, 10th Impression 2021.
2. Jai P. Agrawal, "Power Electronics System Theory and Design", Pearson Education, First Edition, 2015
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", 3rd edition Wiley, 2007.
5. Philip T. Krein, "Elements of Power Electronics" Indian edition Oxford University Press-2017
6. P.C.Sen, "Modern Power Electronics", S.Chand Publishing 2005.
7. P.S.Bimbra, "Power Electronics", Khanna Publishers, Eleventh Edition, 2003
8. Bin Wu, Mehdi Narimani, "High-Power Converters and AC Drives", Wiley, 2nd Edition, 2017

CO-PO MAPPING :

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

PX4102 MODELING AND DESIGN OF SMPS LT P C
3 0 0 3

OBJECTIVES:

1. To inculcate knowledge on steady state analysis of Non-Isolated DC-DC converter
2. To perform steady state analysis of Isolated DC-DC converter
3. To educate on different converter dynamics
4. To impart knowledge on the design of controllers for DC-DC converters
5. To familiarize the 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 - SEPIC topology - design examples - Applications to Battery operated vehicle, PV system.

UNIT II ANALYSIS OF ISOLATED DC-DC CONVERTERS 9

Introduction - classification- forward- flyback- pushpull – half bridge – full bridge topologies- design of SMPS - Applications to Battery operated vehicle

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

OUTCOMES:

After completing the above course, students will be able to

CO1 : Analyse and design Non-Isolated DC-DC converter

CO2: Analyse and design Isolated DC-DC converter

CO3: Derive transfer function of different converters

CO4 : Design controllers for DC-DC converters

CO5 : Design magnetics for SMPS application

TEXT BOOKS:

1. Robert W. Erickson & Dragon Maksimovic, " Fundamentals of Power Electronics", Third Edition, 2020.

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", Wiley,2011, 1st edition.
5. IssaBatarseh, Ahmad Harb, "Power Electronics- Circuit Analysis and Design, Second edition, 2018
6 V.Ramanarayanan, "Course material on Switched mode power conversion", 2007
7. Alex Van den Bossche and VencislavCekovValchev, "Inductors and Transformers for Power Electronics", CRC Press, 1st edition, 2005.
8. W. G. Hurley and W. H.Wolfle, "Transformers and Inductors for Power Electronics Theory, Design and Applications", 2013 Wiley, 1st Edition.

CO-PO MAPPING :

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

RM4151 RESEARCH METHODOLOGY AND IPR

RM4151	RESEARCH METHODOLOGY AND IPR	L T P C
		2 0 0 2

UNIT I RESEARCH DESIGN **6**

Overview of research process and design, Use of Secondary and exploratory data to answer the research question, Qualitative research, Observation studies, Experiments and Surveys.

UNIT II DATA COLLECTION AND SOURCES **6**

Measurements, Measurement Scales, Questionnaires and Instruments, Sampling and methods. Data - Preparing, Exploring, examining and displaying.

UNIT III DATA ANALYSIS AND REPORTING **6**

Overview of Multivariate analysis, Hypotheses testing and Measures of Association. Presenting Insights and findings using written reports and oral presentation.

UNIT IV INTELLECTUAL PROPERTY RIGHTS **6**

Intellectual Property – The concept of IPR, Evolution and development of concept of IPR, IPR development process, Trade secrets, utility Models, IPR & Bio diversity, Role of WIPO and WTO in IPR establishments, Right of Property, Common rules of IPR practices, Types and Features of IPR Agreement, Trademark, Functions of UNESCO in IPR maintenance.

UNIT V PATENTS **6**

Patents – objectives and benefits of patent, Concept, features of patent, Inventive step, Specification, Types of patent application, process E-filling, Examination of patent, Grant of patent, Revocation, Equitable Assignments, Licences, Licensing of related patents, patent agents, Registration of patent agents.

TOTAL : 30 PERIODS

REFERENCES

1. Cooper Donald R, Schindler Pamela S and Sharma JK, "Business Research Methods", Tata McGraw Hill Education, 11e (2012).
2. Catherine J. Holland, "Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets", Entrepreneur Press, 2007.
3. David Hunt, Long Nguyen, Matthew Rodgers, "Patent searching: tools & techniques", Wiley, 2007.
4. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, "Professional Programme Intellectual Property Rights, Law and practice", September 2013.

PX4161	POWER CONVERTERS LABORATORY	L T P C
		0 0 3 1.5

OBJECTIVES:

- To provide the basic understanding of the dynamic behavior of the power electronic switches
- To make the students familiar with the digital processors used in generation of gate pulses for the power electronic switches
- To make the students acquire knowledge on the design of power electronic circuits and implementing the same using simulation tools
- To facilitate the students to design gate drive circuits for power converters
- To provide the fundamentals of DC-AC power converter topologies and analyze the harmonics.

LIST OF EXPERIMENTS:

1. Study of switching characteristics of Power MOSFET & IGBT.
2. Circuit Simulation of Three-phase semi-converter with R,RL& RLE load.
3. Circuit Simulation of Three-phase fully controlled converter with R, RL & RLE load.
4. Circuit Simulation of Three-phase Voltage Source Inverter in 180 and 120 degree mode of conduction
5. Circuit simulation of Three-phase PWM inverter and study of spectrum analysis for various modulation indices.
6. Simulation of Four quadrant operation of DC Chopper.
7. Generation of Gating pulse using Arduino/Micro Controller/PIC microcontroller for a DC-DC converter and single-phase voltage source inverter.
8. Simulation of a single-phase Z-source inverter with R load.
9. Simulation of three-phase AC voltage Controller with R load.
10. Simulation of a five-level cascaded multilevel inverter with R load.
11. Simulation of a Flyback DC-DC converter

TOTAL : 45 PERIODS

OUTCOMES:

CO1: Comprehensive understanding on the switching behaviour of Power Electronic Switches

CO2: Comprehensive understanding on mathematical modeling of power electronic system and ability to implement the same using simulation tools

CO3: Ability of the student to use arduino/microcontroller for power electronic applications

CO4: Ability of the student to design and simulate various topologies of inverters and analyze their harmonic spectrum

CO5: Ability to design and fabricate the gate drive power converter circuits.

Analyze the three-phase controlled rectifiers and isolated DC-DC converters for designing the power supplies

CO-PO MAPPING :

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

PX4111 ANALOG AND DIGITAL CONTROLLERS FOR PE CONVERTERS LABORATORY

L T P C
1 0 3 2.5

OBJECTIVES:

- To understand the concepts related with analog and digital controllers.
- To design and understand the op-amp circuits and microcontroller circuits for power electronics.
- To study and design the driving circuits, sensing circuits, protection circuits for power converters.
- To design and select the appropriate digital controller for power converters along with control strategy

LIST OF EXPERIMENTS:

1. Amplifiers and buffer design and verification by using Opamp
2. Filter design and verification by using Opamp
3. ON/OFF controller design and verification by using analog circuits
4. Design of Driver Circuit using IR2110
5. Waveform generation by using look up table
6. Generation of PWM gate pulses with duty cycle control using PWM peripheral of microcontroller (TI-C2000 family/ PIC18)
7. Duty cycle control from IDE
8. Duty Cycle control using a POT connected to ADC peripheral in a standalone mode
9. Generation of Sine-PWM pulses for a single and three phase Voltage Source Inverter with control of modulation index using PWM peripheral of microcontroller (TI C2000 family/PIC 18)
10. Design and testing of signal conditioning circuit to interface voltage/current sensor with microcontroller (TI-C2000 family/ PIC18)
11. Interface Hall effect voltage and current sensor with microcontroller and display the current waveform in the IDE and validate with actual waveform in DSO
12. Design of closed loop P, I and PI controllers using OP-AMP
13. Design of closed loop P, I and PI controllers using TI-C2000 family/ PIC18

TOTAL : 60 PERIODS

OUTCOMES:

After completing the above course, students will be able to

CO1: Identification of suitable analog and digital controller for the converter design.
CO2: Know the advantages of gate driver, sensing and protection circuits in power converters.
CO3: Hands on with different controller with strategies for design.
CO4: Design and testing the proper driving circuits and protection circuits.
CO5: Fabrication of analog and digital controllers for various real time applications.

CO-PO MAPPING :

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

PX4201 **ANALYSIS OF ELECTRICAL DRIVES** **L T P C**
3 1 0 4

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 12

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.

UNIT II CONVERTER AND CHOPPER CONTROL 12

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 12

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 12

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 12

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 : 60 PERIODS

OUTCOMES:

CO1: Ability 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.

CO5: Ability to design a closed loop motor drive system with controllers for the current and speed control operations.

TEXTBOOKS:

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.

CO-PO MAPPING :

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

PX4202 **SPECIAL ELECTRICAL MACHINES** **L T P C**
3 0 0 3

OBJECTIVES:

- To understand the working, characteristics and speed control principles of stepper motor.
- To study the construction, working, characteristics and speed control methods of switched reluctance motors. .
- To know the principle of operation, construction, characteristics and speed control methods for the permanent magnet brushless DC motors.
- To understand the concepts related with permanent magnet synchronous motors and synchronous reluctance motors.
- To know the features of axial flux machines and its working principles

UNIT I STEPPER MOTORS 9

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

UNIT II SWITCHED RELUCTANCE MOTORS 9

Constructional features –Principle of operation- Torque prediction–Characteristics-Power controllers – Control of SRM drive- Speed control-current control-design procedures- Sensorless operation of SRM – Current sensing- rotor position measurement and estimation methods- sensorless rotor position estimation-inductance based estimation –applications

UNIT III PERMANENT MAGNET BRUSHLESS DC MOTORS 9

Fundamentals of Permanent Magnets- Types- Principle of operation- Magnetic circuit analysis EMF and Torque equations- Characteristics- Controller design-Transfer function –Machine, Load and Inverter-Current and Speed Controller

UNIT IV PERMANENT MAGNET SYNCHROUNOUS MOTORS 9

Permanent Magnet ac Machines, Machine Configurations, PMSM - Principle of operation – EMF and Torque equations - Phasor diagram - Torque speed characteristics – Modeling and small signal equations- evaluation of control characteristics- design of current and speed controllers- Constructional features, operating principle and characteristics of synchronous reluctance motor

UNIT V AXIAL FLUX MACHINES 9

Axial Flux Permanent Magnet Machines- Comparison with Radial Flux Machines- Development-Geometries, Principle of Operation-Torque production - Applications.
Axial flux switched reluctance machine- Topologies and Structures -Operating Principles -Output Equation- Applications

TOTAL : 45 PERIODS

OUTCOMES:

After the completion of this course, student will be able to

CO1: Know the concepts related with stepper motor.
CO2: Understand the working and various characteristics of switched reluctance machines.
CO3: Study the working principle and characteristics of permanent magnet brushless DC motors.
CO4: Know the construction, working principles and characteristics of permanent magnet synchronous motor and synchronous reluctance motor.
CO5: Understand the features of axial flux machines in comparison with radial flux machines and to know the principles of axial flux machines.

REFERENCES:

1.Jacek F. Gieras, Dr. Rong-Jie Wang, Professor Maarten J. Kamper - Axial Flux Permanent Magnet Brushless Machines-Springer Netherlands (2008)
2.Bilgin, Berker_ Emadi, Ali_ Jiang, James Weisheng - Switched reluctance motor drives: fundamentals to applications-CRC (2019)
3.Ramu Krishnan - Permanent Magnet Synchronous and Brushless DC Motor Drives -CRC Press, Marcel Applications -CRC Press (2001)
6.T.Kenjo, ‘ Stepping motors and their microprocessor controls’, Oxford University press, New Delhi, 2000 Dekker (2009)
4.T.J.E. Miller, ‘Brushless magnet and Reluctance motor drives’, Clarendon press, London, 1989
5.R. Krishnan - Switched Reluctance Motor Drives_ Modeling, Simulation, Analysis, Design, and Applications -CRC Press (2001)

CO-PO MAPPING :

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

PX4291 ELECTRIC VEHICLES AND POWER MANAGEMENT **LT P C 3 1 0 4**

OBJECTIVES:

- To understand the concept of electric vehicles and its operations
- To present an overview of Electric Vehicle (EV), Hybrid Electric vehicle (HEV) and their architecture
- To understand the need for energy storage in hybrid vehicles
- To provide knowledge about various possible energy storage technologies that can be used in electric vehicles

UNIT I ELECTRIC VEHICLES AND VEHICLE MECHANICS 12

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

UNIT II ARCHITECTURE OF EV’s AND POWER TRAIN COMPONENTS 12

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

UNIT III POWER ELECTRONICS AND MOTOR DRIVES 12

Electric drive components – Power electronic switches- four quadrant operation of DC drives – Induction motor and permanent magnet synchronous motor-based vector control operation – Switched reluctance motor (SRM) drives- EV motor sizing.

UNIT IV BATTERY ENERGY STORAGE SYSTEM 12

Battery Basics- Different types- Battery Parameters-Battery life & safety impacts -Battery modeling-Design of battery for large vehicles.

UNIT V ALTERNATIVE ENERGY STORAGE SYSTEMS 12

Introduction to fuel cell – Types, Operation and characteristics- proton exchange membrane (PEM) fuel cell for E-mobility– hydrogen storage systems –Super capacitors for transportation applications.

TOTAL : 60 PERIODS

OUTCOMES:

After the completion of this course, students will be able to

CO1: Understand the concept of electric vehicle and energy storage systems.
CO2:Describe the working and components of Electric Vehicle and Hybrid Electric Vehicle
CO3:Know the principles of power converters and electrical drives
CO4:Illustrate the operation of storage systems such as battery and super capacitors
CO5:Analyze the various energy storage systems based on fuel cells and hydrogen storage

REFERENCES:

1. Iqbal Hussain, "Electric and Hybrid Vehicles: Design Fundamentals, Second Edition" CRC Press, Taylor & Francis Group, Second Edition (2011).
2. Ali Emadi, Mehrdad Ehsani, John M.Miller, "Vehicular Electric Power Systems", Special Indian Edition, Marcel dekker, Inc 2010.
3. Mehrdad Ehsani, YiminGao, Sebastian E. Gay, Ali Emadi, 'Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design', CRC Press, 2004.
4. C.C. Chan and K.T. Chau, 'Modern Electric Vehicle Technology', OXFORD University Press, 2001.
5. Wie Liu, "Hybrid Electric Vehicle System Modeling and Control",Second Edition, John Wiley & Sons, 2017.

CO-PO MAPPING :

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	2	3	2
CO2	3	3	3	2	3	2
CO3	3	3	3	2	3	2
CO4	3	3	3	2	3	2
CO5	3	3	3	2	3	2
AVG.	**3**	**3**	**3**	**2**	**3**	**2**

PX4211 POWER ELECTRONICS AND DRIVES LABORATORY

L	T	P	C
0	0	3	1.5

OBJECTIVES:

- To control the speed of DC motor-based drive system.
- To conduct load tests in an electrical drive system.
- To conduct experiments to enhance the understanding of different power electronic controller for motor drive applications.
- To control the speed of Stepper motor and BLDC motor-based drive systems.
- To control the speed of an Induction motor and SRM motor-based drive systems.

LIST OF EXPERIMENTS:

1. Simulation of closed loop control of Converter fed DC drive.
2. Speed control of Converter fed DC motor.
3. Speed control of Chopper fed DC motor.
4. Simulation of VSI fed three phase Induction motor drive.
5. V/f control of Three-Phase Induction motor.
6. Micro controller based speed control of Stepper motor.
7. Speed control of BLDC motor.
8. DSP based speed control of SRM motor.
9. Simulation of Four quadrant operation of three-phase induction motor.
10. Voltage Regulation of three-phase Synchronous Generator.
11. AC voltage Controller based speed control of induction motor.

TOTAL : 45 PERIODS

OUTCOMES:

CO1: Ability to construct the simulation circuit for the closed loop control of drive systems

CO2: Ability to formulate, design the speed controller for DC motor-based drive system.

CO3: Ability to conduct load tests in an electrical drive system.

CO4: Ability to formulate, design the speed controller for AC motor-based drive system.

CO5: Ability to design the control algorithm for the control of an electrical drive using Microcontroller and Digital signal processor.

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.
3. Bimal K Bose “Modern Power Electronics and AC Drives” Pearson Education, Second Edition,2003.
4. Bin Wu, Mehdi Narimani, “High Power Converters and AC Drives, Wiley Publishers, Second Edition,2017.

CO-PO MAPPING:

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

PX4212 **DESIGN LABORATORY FOR POWER ELECTRONICS SYSTEMS** **L T P C 0 0 3 1.5**

OBJECTIVES:

- To design power converter after selecting the suitable component for typical applications
- To design non-isolated and isolated switching mode regulators
- To simulate analyse and test different switching mode regulators

LIST OF EXPERIMENTS:

1. Selection and Design of components (Inductor, Capacitor, transformers and devices) for power converters
2. Design and testing of Isolated converter design and verification (100 W)
3. Design and testing of Non-isolated converter design and verification (100 W)
4. Mini Project Demonstration with applications

TOTAL : 45 PERIODS

OUTCOMES:

CO1: Ability to independently carryout research and development work in power converters
CO2: Ability to demonstrate a degree of mastery over the design and fabrication of switching regulators.
CO3: Ability to apply conceotual basis required for design and testing of various
CO4: Ability to interact with industry to take up problem of societal importance as miniproject designed.
CO5: Ability to compare different possible solution to the same practical problem.

CO-PO MAPPING :

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

PX4001 POWER SEMICONDUCTOR DEVICES LT P C 3 0 0 3

OBJECTIVES:

- To understand the concepts related with power switches and its requirements.
- To know about the developments and characteristics of Silicon Carbide (SiC) and Galium Nitride (GaN) devices..
- To understand the working, steady state and switching characteristics of current controlled and voltage controlled silicon devices.
- To study the working of driving circuits, protection circuits for power devices.
- To understand the thermal characteristics of power devices and the ability to design heat sink for the power devices.

UNIT I INTRODUCTION 9

Power switching devices overview – Attributes of an ideal switch, application requirements, circuit symbols; Power handling capability – (SOA); Power diodes - Types, forward and reverse characteristics, switching characteristics – rating. Features and Brief History of Silicon Carbide-Promise and Demonstration of SiC Power Devices- Physical Properties of Silicon Carbide devices -Unipolar and Bipolar Diodes- GaN Technology Overview

UNIT II CURRENT CONTROLLED DEVICES 9

BJT's – Construction, static characteristics, switching characteristics; Negative temperature coefficient and second breakdown; - Thyristors – Construction, working, static and transient characteristics, types, series and parallel operation; comparison of BJT and Thyristor – steady state and dynamic models of BJT &Thyristor- Basics of GTO, SiC based Bipolar devices-Applications- Building a GaN Transistor -GaN Transistor Electrical Characteristics

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 - and IGCT. New semiconductor materials for devices – Intelligent power modules- study of modules like APTGT100TL170G, MSCSM70TAM05TPAG. Integrated gate commutated thyristor (IGCT) - SiC based unipolar devices-applications

UNIT IV DEVICE SELECTION , DRIVING and PROTECTING CIRCUITS 9

Device selection strategy – On-state and switching losses – EMI due to switching. Necessity of isolation, pulse transformer, optocoupler – Gate drive integrated circuit: Study of Driver IC – IRS2110/2113. SCR, MOSFET, IGBTs and base driving for power BJT. - Over voltage, over current and gate protections; Design of snubbers

UNIT V THERMAL PROTECTION 9

Heat transfer – conduction, convection and radiation; Cooling – liquid cooling, vapour – phase cooling; Guidance for hear sink selection – Thermal resistance and impedance -Electrical analogy of thermal components, heat sink types and design – Mounting types- switching loss calculation for power device

TOTAL : 45 PERIODS

OUTCOMES:

After completing the above course, students will be able to

CO1: Identification of suitable device for the application.
CO2: Know the advantages of Silicon Carbide devices and Galium Nitride devices.
CO3: Understand the principles and characteristics of Silicon devices, Silicon Carbide devices

and Galium Nitride devices.
CO4: Design proper driving circuits and protection circuits.
CO5: Construct a proper thermal protective devices for power semiconductor devices.

REFERENCES:

1. Rashid M.H., " Power Electronics Circuits, Devices and Applications ", Pearson, 4th Edition, 10th Impression 2021.
2. Mohan, Undeland and Robins, "Power Electronics: Converters Applications and Design, Media Enhanced 3rd Edition, Wiley, 2007
3. Tsunenobu Kimoto and James A. Cooper , Fundamentals of Silicon Carbide Technology: Growth, Characterization, Devices, and Applications, First Edition., 2014 John Wiley & Sons Singapore Pte Ltd
4. Alex Lidow, Johan Strydom, Michael de Rooij, David Reusch, GaN Transistors for efficient power conversion, Second Edition, Wiley, 2015
5. Biswanath Paul, Power Electronics, Universities Press 2019

CO-PO MAPPING :

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

PX4002 SYSTEM DESIGN USING MICROCONTROLLER **L T P C**
3 0 0 3

OBJECTIVES:

- To get introduce 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 16 MICROCONTROLLER 9

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

UNIT IV PERIPHERAL OF PIC 16 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- Stand alone Data Acquisition System

TOTAL :45 PERIODS

OUTCOMES:

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.

CO4: Ability to use the peripherals builtin the PIC microcontroller through programming

CO5: Ability to grasp the interfacing concepts involving in the design of microcontroller based systems.

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

CO-PO MAPPING :

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

PX4003 ELECTROMAGNETIC FIELD COMPUTATION AND MODELLING **L T P C**
3 0 0 3

OBJECTIVES:

- To refresh the fundamentals of Electromagnetic Field Theory
- To provide foundation in formulation and computation of electromagnetic field equations using analytical methods
- To impart knowledge in the concept of problem formulation and computation of electromagnetic field equations using numerical methods.
- 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

UNIT III SOLUTION BY NUMERICAL METHODS 9

Finite Difference Method - Finite Element method – Boundary Elimination method - 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.

TOTAL :45 PERIODS

OUTCOMES:

At the end of the course, the students will be able to

CO1: Explain and interpret the concept of Electromagnetic Field Theory.
CO2: Formulate the field problem and apply analytical and numerical method for solving Electromagnetic field problems.
CO3: Formulate Finite Element Methodology for solving Electro Magnetic field problem
CO4: Estimate the basic Electromagnetic field quantities using FEM.
CO5: Design electrical apparatus using FEM

REFERENCES:

1. Matthew. N.O. Sadiku, "Elements of Electromagnetics", Seventh Edition, Oxford University Press, First Indian Edition 2018.
2. K.J.Binns, P.J.Lawrenson, C.W Trowbridge, "The analytical and numerical solution of Electric and magnetic fields", John Wiley & Sons, 1995.
3. Nicola Biyanchi, "Electrical Machine analysis using Finite Elements", Taylor and Francis Group, CRC Publishers, 2005.

4. Nathan Ida, Joao P.A.Bastos, “Electromagnetics and calculation of fields”, Springer-Verlage, 1997.
5. S.J Salon, “Finite Element Analysis of Electrical Machines” Kluwer Academic Publishers, London, Second Edition, 2011, distributed by TBH Publishers & Distributors, Chennai, India.
6. Silvester and Ferrari, “Finite Elements for Electrical Engineers” Cambridge University press, Third Edition 1996.

CO-PO MAPPING :

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

PX4004 SOFT COMPUTING TECHNIQUES

L	T	P	C
3	0	0	3

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.

UNIT I INTRODUCTION AND ARTIFICIAL NEURAL NETWORKS 9

Introduction to intelligent systems- Soft computing techniques- Conventional Computing versus Swarm Computing - Classification of meta-heuristic techniques - Properties of Swarm intelligent Systems - Application domain - Discrete and continuous problems - Single objective and multi-objective problems -Neuron- Nerve structure and synapse- Artificial Neuron and its model- activation functions- Neural network architecture- single layer and multilayer feed forward networks- Mc Culloch Pitts neuron model- perceptron model- Adaline and Madaline- multilayer perception model- back propogation learning methods- effect of learning rule coefficient -back propagation algorithm- factors affecting back propagation training- applications.

UNIT II ARTIFICIAL NEURAL NETWORKS AND ASSOCIATIVE MEMORY 9

Counter propagation network- architecture- functioning & characteristics of counter Propagation network- Hopfield/ Recurrent network configuration - stability constraints associative memory and characteristics- limitations and applications- Hopfield v/s Boltzman machine- Adaptive Resonance Theory- Architecture- classifications- Implementation and training - Associative Memory.

UNIT III FUZZY LOGIC SYSTEM 9

Introduction to crisp sets and fuzzy sets- basic fuzzy set operation and approximate reasoning. Introduction to fuzzy logic modeling and control- Fuzzification inferencing and defuzzification-Fuzzy knowledge and rule bases-Fuzzy modeling and control schemes for nonlinear systems. Self organizing fuzzy logic control- Fuzzy logic control for nonlinear time delay system.

UNIT IV GENETIC ALGORITHM 9

Evolutionary programs – Genetic algorithms, genetic programming and evolutionary programming - Genetic Algorithm versus Conventional Optimization Techniques - Genetic representations and selection mechanisms; Genetic operators- different types of crossover and mutation operators - Optimization problems using GA-discrete and continuous - Single objective and multi-objective problems - Procedures in evolutionary programming.

UNIT V HYBRID CONTROL SCHEMES 9

Fuzzification and rule base using ANN–Neuro fuzzy systems-ANFIS – Fuzzy Neuron - Optimization of membership function and rule base using Genetic Algorithm –Introduction to Support Vector Machine- Evolutionary Programming-Particle Swarm Optimization - Case study – Familiarization of NN, FLC and ANFIS Tool Box.

TOTAL : 45 PERIODS

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

TEXT BOOKS:

1. Laurene V. Fausett, “Fundamentals of Neural Networks: Architectures, Algorithms And Applications”, Pearson Education.
2. Timothy J. Ross, “Fuzzy Logic with Engineering Applications” Wiley India, 2008.
3. Zimmermann H.J. "Fuzzy set theory and its Applications" Springer international edition, 2011.
4. David E.Goldberg, “Genetic Algorithms in Search, Optimization, and Machine Learning”, Pearson Education, 2009.
5. W.T.Miller, R.S.Sutton and P.J.Webrose, “Neural Networks for Control” MIT Press”, 1996.
6. T. Ross, “Fuzzy Logic with Engineering Applications”, Tata McGraw Hill, New Delhi, 1995.
7. EthemAlpaydin, “Introduction to Machine Learning (Adaptive Computation and Machine Learning Series)”, MIT Press, 2004.
8. Corinna Cortes and V. Vapnik, " Support - Vector Networks, Machine Learning ” 1995.

CO-PO MAPPING :

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

PS4151 **SYSTEM THEORY** **L T P C**
3 0 0 3

OBJECTIVES:

1. To educate on modeling and representing systems in state variable form.
2. To train on solving linear and non-linear state equations.
3. To illustrate the properties of control system.
4. To classifynon–linearitiesand examine stability of systems in the sense of Lyapunov's theory.
5. To educate on modal concepts, design of state, output feedback controllers and estimators.

UNIT I STATE VARIABLE REPRESENTATION 9

Introduction-Concept of State-Space equations for Dynamic Systems -Time invariance and linearity- Non uniqueness of state model- Physical Systems and State Assignment - free and forced responses- State Diagrams.

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 - State transition matrix and its properties – Evaluation of matrix exponential- System modes- Role of Eigen values and Eigen vectors.

UNIT III PROPERTIES OF THE CONTROL SYSTEM 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 NON-LINEARITIES AND STABILITY ANALYSIS 9

Equilibrium Points-Stability in the sense of Lyapunov-BIBO Stability-Stability of LTI Systems-Types of nonlinearity – Phase plane analysis – Singular points – Limit cycles – Construction of phase trajectories – Describing function method – Derivation of describing functions. Equilibrium Stability of Nonlinear Continuous Time Autonomous Systems - Direct Method of Lyapunov and the Linear Continuous-Time Autonomous Systems- Lyapunov Functions for Nonlinear Continuous Time Autonomous Systems-Krasovskii and Variable-Gradiant Method

UNIT IV MODAL ANALYSIS 9

Controllable and Observable Companion Forms - SISO and MIMO Systems – 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

OUTCOMES:

Students able to

CO1 Understand the concept of State-State representation for Dynamic Systems
CO2 Explain the solution techniques of state equations
CO3 Realize the properties of control systems in state space form
CO4 Identify non-linearities and evaluate the stability of the system using Lyapnov notion
CO5 Perform Modal analysis and design controller and observer in state space form

REFERENCES:

1. M. Gopal, "Modern Control System Theory", New Age International, 2005.
2. Z. Bubnicki, "Modern Control Theory", Springer, 2005
3. K. Ogatta, "Modern Control Engineering", PHI, 2002
4. John S. Bay, "Fundamentals of Linear State Space Systems", McGraw-Hill, 1999
5. D. Roy Choudhury, "Modern Control Systems", New Age International, 2005
6. John J. D'Azzo, C. H. Houpis and S. N. Sheldon, "Linear Control System Analysis and Design with MATLAB", Taylor Francis, 2003
7. M. Vidyasagar, "Nonlinear Systems Analysis', 2nd edition, Prentice Hall, Englewood Cliffs, New Jersey, 2002

MAPPING OF CO’S WITH PO’S

CO	PO					
	1	2	3	4	5	6
1	3	-	2	2	3	-
2	2	2	3	-	2	3
3	3	-	3	-	-	-
4	3	-	3	2	2	-
5	3	-	3	2	3	2
AVG	2.8	2	2.8	3	2.5	2.5

PX4005 POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS **LT P C 3 0 0 3**

OBJECTIVES:

- To provide knowledge about different types of renewable energy systems.
- To analyze the various electrical Generators used for the Wind Energy Conversion Systems.
- To design a power converter used in renewable energy systems such as AC-DC, DC-DC, and AC-AC converters.
- To understand the importance of standalone, grid-connected, and hybrid operation in renewable energy systems.
- To analyse various maximum power point tracking algorithms

UNIT I INTRODUCTION TO RENEWABLE ENERGY SYSTEMS 9

Classification of Energy Sources – Importance of Non-conventional energy sources – Advantages and disadvantages of conventional energy sources - Environmental aspects of energy - Impacts of renewable energy generation on the environment - Qualitative study of renewable energy resources: Ocean energy, Biomass energy, Hydrogen energy, - Solar Photovoltaic (PV), Fuel cells: Operating principles and characteristics, Wind Energy: Nature of wind, Types, control strategy, operating area

UNIT II ELECTRICAL MACHINES FOR WIND ENERGY CONVERSION SYSTEMS (WECS) 9

Review of reference theory fundamentals –Construction, Principle of operation and analysis: Squirrel Cage Induction Generator (SCIG), Doubly Fed Induction Generator (DFIG) - Permanent Magnet Synchronous Generator (PMSG).

UNIT III POWER CONVERTERS AND ANALYSIS OF SOLAR PV SYSTEMS 9

Power Converters: Line commutated converters (inversion-mode) - Boost and buck-boost converters- selection of inverter, battery sizing, array sizing.

Analysis: Block diagram of the solar PV systems - Types of Solar PV systems: Stand-alone PV systems, Grid integrated solar PV Systems - Grid connection Issues

UNIT IV POWER CONVERTERS AND ANALYSIS OF WIND SYSTEMS 9

Power Converters: Three-phase AC voltage controllers- AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, Grid-Interactive Inverters - Matrix converter.

Analysis: Stand-alone operation of fixed and variable speed WECS-Grid integrated SCIG and PMSG based WECS.

UNIT V HYBRID RENEWABLE ENERGY SYSTEMS 9

Need for Hybrid Systems- Range and type of Hybrid systems- Case studies of Diesel-PV, Wind-PV, Microhydel-PV, Biomass-Diesel systems - Maximum Power Point Tracking (MPPT).

TOTAL : 45 PERIODS

OUTCOMES:

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

CO1: Analyze the impacts of renewable energy technologies on the environment and demonstrate them to harness electrical power.

CO2: Select a suitable Electrical machine for Wind Energy Conversion Systems.

CO3: Design the power converters such as AC-DC, DC-DC, and AC-AC converters for Solar energy systems.

CO4: Design the power converters such as AC-DC, DC-DC, and AC-AC converters for Wind energy systems.

CO5: Interpret the stand-alone, grid-connected, and hybrid renewable energy systems with MPPT.

REFERENCES:

1. S.N.Bhadra, D. Kastha, & S. Banerjee "Wind Electrical Systems", Oxford University Press, 2009
2. Rashid .M. H "Power electronics Hand book", Academic press,2nd Edition, 2006.
3. Rai. G.D, "Non-conventional energy sources", Khanna publishers, 2010.
4. Rai. G.D," Solar energy utilization", Khanna publishers, 5th Edition, 2008.
5. Gray, L. Johnson, "Wind energy system", prentice hall of india, 1995.
6. B.H.Khan "Non-conventional Energy sources ",Tata McGraw-hill Publishing Company, New Delhi, 2017.

CO-PO MAPPING :

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

PX4006 **MODERN RECTIFIERS AND RESONANT CONVERTERS** **L T P C 3 0 0 3**

OBJECTIVES:

- To inculcate knowledge on harmonics standards.
- To impart knowledge on the design power factor correction rectifiers for UPS applications.
- To familiarize the design resonant converters for SMPS applications.
- To provide knowledge on 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 an AC waveform-Power factor-AC line current harmonic standards IEC 1000-IEEE 519- The Single phase full wave rectifier-Continuous Conduction Mode-Discontinuous Conduction Mode-Single phase Rectifier's behavior for large value of Capacitance -Minimizing THD for small value of Capacitance- Three phase rectifiers- Continuous Conduction Mode-Discontinuous Conduction Mode- Introduction to Harmonic trap filters.

UNIT II PULSE WIDTH MODULATED RECTIFIERS 9

Properties of Ideal rectifiers-Realization of non-ideal rectifier-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.

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 and Zero Voltage Switching of Quasi Resonant Buck converter- Zero Current and 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 PWM RECTIFIRS 9

Pulse Width Modulation-Voltage Mode PWM Scheme-Current Mode PWM Scheme- Average current control-Current programmed Control- Hysteresis control- Nonlinear carrier control -Design of Controllers: PI Controller, Variable Structure Controller for source current shaping of PWM rectifiers.

TOTAL : 45 PERIODS

OUTCOMES:

CO1: To understand the standards for supply current harmonics and its significance.

CO2: To design power factor correction rectifiers for UPS applications.

CO3: To analyze and design the resonant converters.

CO4: To derive the state space model of basic and derived DC-DC converters.

CO5: To design an appropriate controller for PWM rectifiers.

REFERENCES:

1. John G. Kassakian, Martin F. Schlecht, George C. Verghese, "Principles of Power Electronics", Pearson, India, New Delhi, 2010
2. Philip T Krein, " Elements of Power Electronics", Oxford University Press,1998
3.Ned Mohan, "Power Electronics: A first course", John Wiley,2011
4.IssaBatarseh, Ahmad Harb, "Power Electronics- Circuit Analysis and Design, Second edition,2018

CO-PO Mapping:

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

PX4007 ADVANCED POWER CONVERTERS L T P C
3 0 0 3

OBJECTIVES:

- To study the operation of voltage lift circuits
- To impart knowledge on the working of super lift circuits
- To learn the operation of ultra lift converters and multiple quadrant converters.
- To provide knowledge on the principle of bidirectional dual active bridge converters
- To educate on 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 converter- continuous and discontinuous conduction mode.-Applications

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 and discontinuous conduction modes- Applications

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

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

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 mode control- Principle of Dual-Transformer based DAB converter- Three-Level bidirectional DC–DC converter- Applications

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- Applications

TOTAL :45 PERIODS

OUTCOMES:

After completing the above course, students will be able to

CO1 : Understand the working of voltage lift circuits

CO2: Design the super lift converters

CO3 : Understand the working and applications of ultra-lift converters

CO4 : Acquire knowledge on working and design of bi-directional DC-DC converters

CO5 : Understand the concepts related with impedance source converter

TEXT BOOKS

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

REFERENCE BOOKS

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

COPO-MAPPING:

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

PX4009 CONTROL OF POWER ELECTRONIC CIRCUITS **L T P C**
3 0 0 3

OBJECTIVES:

- To inculcate knowledge on the basics of control for power electronic circuits
- To illustrate the concepts of feedback controllers for DC-DC converters
- To learn about the controller design for AC-DC converter circuits
- To impart knowledge on sliding mode control
- To equip with required skills to design flatness-based controllers

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

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

OUTCOMES:

After completing the above course, students will be able to

CO1 : Design controller for front end power factor corrector circuits.

CO2: Design controllers for UPS application.

CO3: Design controllers for AC-DC converters.

CO4 : Design sliding mode control for power converters.

CO5 : Design flatness based control for power converters.

TEXT BOOKS:

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

REFERENCE BOOKS:

1. FarzinAsadi and Kei Eguchi, Morgan &Claypool,"Dynamics and Control of DC-DC Converters", 2018
2. Andre Kislovski, "Dynamic Analysis of Switching-Mode DC/DC Converters" ,Springer 1991
3. Azar, Ahmad Taher, Zhu, Quannmin," Advances and Applications in sliding mode control systems" Springer, 2015
4. Levine, Jean, "Analysis and control of Non-linear systems A flatness-based approach" Springer, 2009

CO-PO MAPPING :

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

PS4072 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
  - To study the various applications of energy storage systems

UNIT I INTRODUCTION 9

Necessity of energy storage – types of energy storage –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,

UNIT III ELECTRICAL ENERGY STORAGE 9

Fundamental concept of batteries – Measuring of battery performance, charging and dis charging of a battery, storage density, energy density, and safety issues - Types of batteries: – Lead Acid, Nickel-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:

Upon Completion of this course, the students will be able to
CO1:Understand the physics of energy storage
CO2: Model the different energy technologies.
CO3: Recognize the applications of various techniques.
CO4: Design and analyze the energy storage technologies.
CO5: Select and apply the appropriate technique based on the application.

REFERENCES

1. James Larminie and Andrew Dicks, 'Fuel cell systems Explained', Wiley publications, 2003.
2. LunardiniV.J, "Heat Transfer in Cold Climates", John Wiley and Sons 1981.
3. Jiujun Zhang (Editor), Lei Zhang (Editor), Hansan Liu (Editor), Andy Sun (Editor), Ru-Shi Liu (Editor), "Electrochemical technologies for energy storage and conversion", Two Volume Set, Wiley publications, 2012
4. Schmidt.F.W. and Willmott.A.J., "Thermal Storage and Regeneration", Hemisphere Publishing Corporation, 1981
5. Luisa F. Cabeza (Editor), "Advances in Thermal Energy Storage Systems: Methods and Applications", Woodhead Publishers, 2020.
6. Ibrahim Dinçer and Marc A. Rosen, "Thermal Energy Storage Systems and Applications", Wiley Publishers, 2021.

MAPPING OF CO'S WITH PO'S

CO	PO					
	1	2	3	4	5	6
1	-	1	-	-	2	-
2	2	1	2	-	3	-
3	2	2	2	-	3	-
4	3	2	3	-	3	3
5	2	2	2	2	2	3
AVG	2.25	1.6	2.25	1	2.6	3

PX4071 POWER QUALITY L T P C
3 0 0 3

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 techniques for power factor correction and load voltage regulation.
- To introduce the control techniques for the active compensation.
- To understand the mitigation techniques using custom power devices such as DSTATCOM, DVR & UPQC

UNIT I INTRODUCTION 9

Introduction – Characterization of Electric Power Quality: Transients, short duration and long duration voltage variations, Voltage imbalance, waveform distortion, Voltage fluctuations, Power frequency variation, Power acceptability curves – power quality problems: poor load power factor, 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 loads – three phase balanced system – three phase unbalanced system – three phase unbalanced and distorted source supplying non-linear loads – concept of power factor – 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

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

OUTCOMES:

After completing the above course, students will be able to

CO1: comprehend the consequences of Power Quality issues.

CO2: conduct harmonic analysis of single phase and three phase systems supplying non-linear loads.

CO3: design passive filter for load compensation.

CO4: design active filters for load compensation.

CO5: understand the mitigation techniques using custom power devices such as distribution static compensator (DSTATCOM), dynamic voltage restorer (DVR) & UPQC.

TEXTBOOKS:

1.Arindam Ghosh and Gerad Ledwich "Power Quality Enhancement Using Custom Power Devices",Kluwer Academic Publishers, First Edition,2002

2.G.T.Heydt, "Electric Power Quality", Stars in a Circle Publications, Second Edition, 1994

REFERENCES:

1. R.C.Duggan "Electric Power Systems Quality", Tata MC Graw Hill Publishers, Third Edition,2012
2. Arrillga "Power System Harmonics", John Wiely and Sons,2003
3. Derek A.Paice "Power Electronic Converter Harmonics" IEEE Press, 1995

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	3	3	3	2
CO2	3	-	3	3	3	2
CO3	3	-	3	3	3	2
CO4	3	-	3	3	3	2
CO5	3	-	3	3	3	2
AVG	**3**	-	**3**	**3**	**3**	**2**

ET4071 **DSP BASED SYSTEM DESIGN** **L T P C**
3 0 0 3

COURSE OBJECTIVES:

1. To understand various representation methods of DSP system
2. To provide insight about different DSP algorithms
3. To familiarize the various architectures of DSP system
4. To perform analysis of DSP architectures and to learn the implementation of DSP system in programmable hardware
5. To learn the details of DSP system interfacing with other peripherls

UNIT I REPRESENTATION OF DSP SYSTEM 9

Single Core and Multicore, Architectural requirement of DSPs - high throughput, low cost, low power, small code size, embedded applications. Representation of digital signal processing systems - block diagrams, signal flow graphs, data-flow graphs, dependence graphs. Techniques for enhancing computational throughput - parallelism and pipelining.

UNIT II DSP ALGORITHMS 9

DSP algorithms - Convolution, Correlation, FIR/IIR filters, FFT, adaptive filters, sampling rate converters, DCT, Decimator, Expander and Filter Banks. DSP applications. Computational characteristics of DSP algorithms and applications, Numerical representation of signals-word length effect and its impact, Carry free adders, Multiplier.

UNIT III SYSTEM ARCHITECTURE 9

Introduction, Basic Architectural Features, DSP Computational Building Blocks, Bus Architecture and Memory, Data Addressing Capabilities, Address Generation Unit, Programmability and Program Execution, Features for External Interfacing. VLIW architecture. Basic performance issue in pipelining, Simple implementation of MIPS, Instruction Level Parallelism, Dynamic Scheduling, Dynamic Hardware Prediction, Memory hierarchy.Study of FIxed point and floating point DSP architectures

UNIT IV ARCHITECTURE ANALYSIS ON PROGRAMMABLE HARDWARE 9

Analysis of basic DSP Architectures on programmable hardwares. Algorithms for FIR , IIR, Lattice filter structures, architectures for real and complex fast Fourier transforms, 1D/2D Convolutions, Winograd minimal filtering algorithm. FPGA: Architecture, different sub-systems, design flow for DSP system design, mapping of DSP algorithms onto FPGA.

UNIT V SYSTEM INTERFACING 9

Examples of digital signal processing algorithms suitable for parallel architectures such as GPUs and multiGPUs. Interfacing: Introduction, Synchronous Serial Interface CODE, A CODEC Interface Circuit, ADC interface.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

At the end of this course, the students will have the ability in

CO 1: Evaluate the DSP system using various methods.
CO 2: Design algorithm suitable for different DSP applications.
CO 3: Explain various architectures of DSP system.
CO 4: Implement DSP system in programmable hardware.
CO 5: Build interfacing of DSP system with various peripherals.

CO	PO					
	1	2	3	4	5	6
1	-	3	-	-	-	-
2	3	3	3	2	3	2
3	-	3	-	-	-	-
4	3	-	3	3	3	3
5	2	-	3	2	3	3
Avg.	2.67	3	3	2.33	3	2.67

REFERENCES

1. Sen M Kuo, Woon Seng S Gan, Digital Signal Processors
2. Digital Signal Processing and Application with C6713 and C6416 DSK, Rulph Chassaing, Worcester Polytechnic Institute, A Wiley Interscience Publication
3. Architectures for Digital Signal Processing, Peter Pirsch John Weily, 2007
4. DSP Processor and Fundamentals: Architecture and Features. Phil Lapsley, JBier, AmitSohan, Edward A Lee; Wiley IEEE Press
5. K. K. Parhi - VLSI Digital Signal Processing Systems - Wiley – 1999.
6. RulphChassaing, Digital signal processing and applications with C6713 and C6416 DSK, Wiley, 2005
7. Keshab K Parhi, VLSI Digital Signal Processing Systems:Design and Implementation, student Edition, Wiley, 1999.
8. Nasser Kehtarnavaz, Digital Signal Processing System Design: LabVIEW-Based Hybrid Programming, Academic Press, 2008

ET4072 MACHINE LEARNING AND DEEP LEARNING L T P C
3 0 0 3

COURSE OBJECTIVES:

The course is aimed at

1. Understanding about the learning problem and algorithms
2. Providing insight about neural networks
3. Introducing the machine learning fundamentals and significance
4. Enabling the students to acquire knowledge about pattern recognition.
5. Motivating the students to apply deep learning algorithms for solving real life problems.

UNIT I LEARNING PROBLEMS AND ALGORITHMS 9

Various paradigms of learning problems, Supervised, Semi-supervised and Unsupervised algorithms

UNIT II NEURAL NETWORKS 9

Differences between Biological and Artificial Neural Networks - Typical Architecture, Common Activation Functions, Multi-layer neural network, Linear Separability, Hebb Net, Perceptron, Adaline, Standard Back propagation Training Algorithms for Pattern Association - Hebb rule and Delta rule, Hetero associative, Auto associative, Kohonen Self Organising Maps, Examples of Feature Maps, Learning Vector Quantization, Gradient descent, Boltzmann Machine Learning.

UNIT III MACHINE LEARNING – FUNDAMENTALS & FEATURE SELECTIONS & CLASSIFICATIONS 9

Classifying Samples: The confusion matrix, Accuracy, Precision, Recall, F1- Score, the curse of dimensionality, training, testing, validation, cross validation, overfitting, under-fitting the data, early stopping, regularization, bias and variance. Feature Selection, normalization, dimensionality reduction, Classifiers: KNN, SVM, Decision trees, Naïve Bayes, Binary classification, multi class classification, clustering.

UNIT IV DEEP LEARNING: CONVOLUTIONAL NEURAL NETWORKS 9

Feed forward networks, Activation functions, back propagation in CNN, optimizers, batch normalization, convolution layers, pooling layers, fully connected layers, dropout, Examples of CNNs.

UNIT V DEEP LEARNING: RNNS, AUTOENCODERS AND GANS 9

State, Structure of RNN Cell, LSTM and GRU, Time distributed layers, Generating Text, Autoencoders: Convolutional Autoencoders, Denoising autoencoders, Variational autoencoders, GANs: The discriminator, generator, DCGANs

TOTAL : 45 PERIODS

COURSE OUTCOMES (CO):

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

CO1 : Illustrate the categorization of machine learning algorithms.

CO2: Compare and contrast the types of neural network architectures, activation functions

CO3: Acquaint with the pattern association using neural networks

CO4: Elaborate various terminologies related with pattern recognition and architectures of convolutional neural networks

CO5: Construct different feature selection and classification techniques and advanced neural network architectures such as RNN, Autoencoders, and GANs.

CO	PO					
	1	2	3	4	5	6
1	1	3	1	-	-	-
2	2	3	2	-	-	-
3	3	-	3	-	3	-
4	2	3	3	-	-	-
5	3	3	3	-	3	-
6	3	3	3	-	3	-
7	3	3	3	-	3	-
Avg.	2.42	3	2.57	-	3	-

REFERENCES:

1. J. S. R. Jang, C. T. Sun, E. Mizutani, Neuro Fuzzy and Soft Computing - A Computational Approach to Learning and Machine Intelligence, 2012, PHI learning
2. Deep Learning, Ian Good fellow, YoshuaBengio and Aaron Courville, MIT Press, ISBN: 9780262035613, 2016.
3. The Elements of Statistical Learning. Trevor Hastie, Robert Tibshirani and Jerome Friedman. Second Edition. 2009.
4. Pattern Recognition and Machine Learning. Christopher Bishop. Springer. 2006.
5. Understanding Machine Learning. Shai Shalev-Shwartz and Shai Ben-David. Cambridge University Press. 2017.

ET4251 IoT FOR SMART SYSTEMS LT P C
3 0 0 3

COURSE OBJECTIVES:

1. To study about **Internet of Things** technologies and its role in real time applications.
2. To introduce the infrastructure required for IoT
3. To familiarize the accessories and communication techniques for IoT.
4. To provide insight about the embedded processor and sensors required for IoT
5. To familiarize the different platforms and Attributes for IoT

UNIT I INTRODUCTION TO INTERNET OF THINGS 9

Overview, Hardware and software requirements for IOT, Sensor and actuators, Technology drivers, Business drivers, Typical IoT applications, Trends and implications.

UNIT II IOT ARCHITECTURE 9

IoT reference model and architecture -Node Structure - Sensing, Processing, Communication, Powering, Networking - Topologies, Layer/Stack architecture**,** IoT standards, Cloud computing for IoT, Bluetooth, Bluetooth Low Energy beacons.

UNIT III PROTOCOLS AND WIRELESS TECHNOLOGIES FOR IOT 9
PROTOCOLS:

NFC, SCADA and RFID, Zigbee MIPI, M-PHY, UniPro, SPMI, SPI, M-PCIe GSM, CDMA, LTE, GPRS, small cell.

Wireless technologies for IoT: WiFi (IEEE 802.11), Bluetooth/Bluetooth Smart, ZigBee/ZigBee Smart, UWB (IEEE 802.15.4), 6LoWPAN, Proprietary systems-Recent trends.

UNIT IV IOT PROCESSORS 9

Services/Attributes: Big-Data Analytics for IOT, Dependability,Interoperability, Security, Maintainability.

Embedded processors for IOT :Introduction to Python programming -Building IOT with RASPERRY PI and Arduino.

UNIT V CASE STUDIES 9

Industrial IoT, Home Automation, smart cities, Smart Grid, connected vehicles, electric vehicle charging, Environment, Agriculture, Productivity Applications, IOT Defense

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of this course, the students will have the ability to
CO1: Analyze the concepts of IoT and its present developments.
CO2: Compare and contrast different platforms and infrastructures available for IoT
CO3: Explain different protocols and communication technologies used in IoT
CO4: Analyze the big data analytic and programming of IoT
CO5: Implement IoT solutions for smart applications

CO	PO					
	1	2	3	4	5	6
1	1	2	1	-	-	-
2	-	2	-	-	-	-
3	1	2	-	1	3	-
4	2		3	3	3	3
5	3	2	3	3	3	3
Avg.	1.75	2	2.33	2.33	3	2

REFERENCES:

1. ArshdeepBahga and VijaiMadisetti : A Hands-on Approach "Internet of Things",Universities Press 2015.
2. Oliver Hersent , David Boswarthick and Omar Elloumi " The Internet of Things", Wiley,2016.
3. Samuel Greengard, " The Internet of Things", The MIT press, 2015.
4. Adrian McEwen and Hakim Cassimally"Designing the Internet of Things "Wiley,2014.
5. Jean- Philippe Vasseur, Adam Dunkels, "Interconnecting Smart Objects with IP: The Next Internet" Morgan Kuffmann Publishers, 2010.
6. Adrian McEwen and Hakim Cassimally, "Designing the Internet of Things", John Wiley and sons, 2014.
7. Lingyang Song/DusitNiyato/ Zhu Han/ Ekram Hossain," Wireless Device-to-Device Communications and Networks, CAMBRIDGE UNIVERSITY PRESS,2015.
8. OvidiuVermesan and Peter Friess (Editors), "Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems", River Publishers Series in Communication, 2013.
9. Vijay Madisetti , ArshdeepBahga, "Internet of Things (A Hands on-Approach)", 2014.
10. Zach Shelby, Carsten Bormann, "6LoWPAN: The Wireless Embedded Internet", John Wiley and sons, 2009.
11. Lars T.Berger and Krzysztof Iniewski, "Smart Grid applications, communications and security", Wiley, 2015.
12. JanakaEkanayake, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama and Nick Jenkins, " Smart Grid Technology and Applications", Wiley, 2015.
13. UpenaDalal,"Wireless Communications & Networks,Oxford,2015.

ET4018	**MEMS DESIGN: SENSORS AND ACTUATORS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

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

OUTCOMES:

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

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.

CO-PO MAPPING :

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

PX4010 **NONLINEAR DYNAMICS FOR POWER ELECTRONICS CIRCUITS** **L T P C**
3 0 0 3

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

OUTCOMES:

CO1 Ability 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
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.

CO-PO MAPPING :

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

PX4011 GRID INTEGRATION OF RENEWABLE ENERGY SOURCES

L	T	P	C
3	0	0	3

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

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.

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.
6. S.P. Sukhatme, 'Solar Energy', Tata McGraw Hill, 1987.
7. Chetan Singh Solanki, 'Solar Photovoltaic Technology and Systems' – A Manual for Technicians, Trainees and Engineers, PHI, 2014.

CO-PO MAPPING :

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

PX4012 RENEWABLE ENERGY TECHNOLOGY L T P C
3 0 0 3

OBJECTIVES:

To impart knowledge on

- Different types of renewable energy technologies
- Standalone operation, grid connected operation of renewable energy systems

UNIT I INTRODUCTION 9

Classification of energy sources – Co2 Emission - Features of Renewable energy - Renewable energy scenario in India -Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment Per Capital Consumption - CO_2 Emission - importance of renewable energy sources, Potentials – Achievements– Applications.

UNIT II SOLAR PHOTOVOLTAICS 9

Solar Energy: Sun and Earth-Basic Characteristics of solar radiation- angle of sunrays on solar collector-Estimating Solar Radiation Empirically - Equivalent circuit of PV Cell- Photovoltaic cell-characteristics: P-V and I-V curve of cell-Impact of Temperature and Insolation on I-V characteristics-Shading Impacts on I-V characteristics-Bypass diode -Blocking diode.

UNIT III PHOTOVOLTAIC SYSTEM DESIGN 9

Block diagram of solar photo voltaic system : Line commutated converters (inversion mode) - Boost and buck-boost converters - selection of inverter, battery sizing, array sizing - PV systems classification- standalone PV systems - Grid tied and grid interactive inverters- grid connection issues.

UNIT IV WIND ENERGY CONVERSION SYSTEMS 9

Origin of Winds: Global and Local Winds- Aerodynamics of Wind turbine-Derivation of Betz's limit-Power available in wind-Classification of wind turbine: Horizontal Axis wind turbine and Vertical axis wind turbine- Aerodynamic Efficiency-Tip Speed-Tip Speed Ratio-Solidity-Blade Count-Power curve of wind turbine - Configurations of wind energy conversion systems: Type A, Type B, Type C and Type D Configurations- Grid connection Issues - Grid integrated SCIG and PMSG based WECS.

UNIT V OTHER RENEWABLE ENERGY SOURCES 9

Qualitative study of different renewable energy resources: ocean, Biomass, Hydrogen energy systems, Fuel cells, Ocean Thermal Energy Conversion (OTEC), Tidal and wave energy, Geothermal Energy Resources.

TOTAL : 45 PERIODS

OUTCOMES:

After completion of this course, the student will be able to:

CO1: Demonstrate the need for renewable energy sources.
CO2: Develop a stand-alone photo voltaic system and implement a maximum power point tracking in the PV system.
CO3: Design a stand-alone and Grid connected PV system.
CO4: Analyze the different configurations of the wind energy conversion systems.
CO5: Realize the basic of various available renewable energy sources

REFERENCES:

1. S.N.Bhadra, D. Kastha, & S. Banerjee "Wind Electrical Systems", Oxford UniversityPress, 2009.
2. Rai. G.D, "Non conventional energy sources", Khanna publishes, 1993.
3. Rai. G.D," Solar energy utilization", Khanna publishes, 1993.
4. Chetan Singh Solanki, "Solar Photovoltaics: Fundamentals, Technologies and Applications", PHI Learning Private Limited, 2012.
5. John Twideu and Tony Weir, "Renewal Energy Resources" BSP Publications, 2006
6. Gray, L. Johnson, "Wind energy system", prentice hall of India, 1995.
7. B.H.Khan, " Non-conventional Energy sources", , McGraw-hill, 2nd Edition, 2009.
8. Fang Lin Luo Hong Ye, " Renewable Energy systems", Taylor & Francis Group,2013.

CO-PO MAPPING :

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

PX4013	WIND ENERGY CONVERSION SYSTEM	L	T	P	C
		3	0	0	3

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 systems.
- To analyze the grid integration issues.

UNIT I 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

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.

REFERENCES:

1. L.L.Freris “Wind Energy conversion Systems”, Prentice Hall,1990
2. S.N.Bhadra, D.Kastha,S.Banerjee, ”Wind Electrical Systems”, Oxford University Press,2010.
3. Ion Boldea, “Variable speed generators”, Taylor & Francis group,2006.
4. E.W.Golding “The generation of Electricity by wind power”, Redwood burn Ltd., Trowbridge,1976.
5. N. Jenkins,” Wind Energy Technology” John Wiley &Sons,1997
6. S.Heir “Grid Integration of WECS”, Wiley1998

CO-PO MAPPING :

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

PX4014 **OPTIMIZATION TECHNIQUES** **L T P C**
3 0 0 3

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.

UNIT I INTRODUCTION 9

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

UNIT II 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.

UNIT III NON LINEAR PROGRAMMING 9

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

UNIT IV DYNAMIC PROGRAMMING (DP) 9

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

UNIT V 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

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 to power system optimization.

REFERENCES:

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.

CO-PO MAPPING :

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

PS4091 DISTRIBUTED GENERATION AND MICRO GRID **L T P C**
3 0 0 3

COURSE OBJECTIVES:

- To familiarize with the concept of Distributed Generation
- To expose the various distributed energy resources
- To focus on the planning and protection of Distributed Generation
- To study the concept of MicroGrid and to analyze the impact of MicroGrid
- To understand the major issues on MicroGrid economics

UNIT I INTRODUCTION TO DISTRIBUTED GENERATION 9

DG definition - Reasons for distributed generation-Benefits of integration - Distributed generation and the distribution system - Technical, Environmental and Economic impacts of distributed generation on the distribution system - Impact of distributed generation on the transmission system-Impact of distributed generation on central generation

UNIT II DISTRIBUTED ENERGY RESOURCES 9

Combined heat and power (CHP) systems-Wind energy conversion systems (WECS)- Solar photovoltaic (PV) systems-Small-scale hydroelectric power generation-Other renewable energy sources-Storage devices-Inverter interfaces

UNIT III DG PLANNING AND PROTECTION 9

Generation capacity adequacy in conventional thermal generation systems-Impact of distributed generation-Impact of distributed generation on network design-Protection of distributed generation-Protection of the generation equipment from internal Faults-Protection of the faulted distribution network from fault currents supplied by the distributed generator-Impact of distributed generation on existing distribution system protection.

UNIT IV CONCEPT OF MICROGRID 9

Microgrid Definition-A typical Microgrid configuration- Functions of Micro source controller and central controller- Energy Management Module (EMM) and Protection Co-ordination Module (PCM)- Modes of Operation- Grid connected and islanded modes- Modelling of Microgrid-Microturbine Model- PV Solar Cell Model- Wind Turbine Model-Role of Microgrid in power market competition.

UNIT V IMPACTS OF MICROGRID 9

Technical and economical advantages of Microgrid-Challenges and disadvantages of Microgrid development-Management and operational issues of a Microgrid- Impact on heat utilization-Impact on process optimization-Impact on market-Impact on environment-Impact on distribution system-Impact on communication standards and protocols.

Microgrid economics-Main issues of Microgrid economics-Microgrids and traditional power system economics-Emerging economic issues in Microgrids-Economic issues between Microgrids and bulk power systems-Potential benefits of Microgrid economics.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Students able to

CO1: Understand the concepts of Distributed Generation and Microgrids.

CO2: Gain Knowledge about the various DG resources.

CO3: Familiarize with the planning and protection schemes of Distributed Generation.

CO4: Learn the concept of Microgrid and its mode of operation.

CO5: Acquire knowledge on the impacts of Microgrid.

REFERENCES:

1. Nick Jenkins, JanakaEkanayake , GoranStrbac , "Distributed Generation", Institution of Engineering and Technology, London, UK,2010.
2. S. Chowdhury, S.P. Chowdhury and P. Crossley, "Microgrids and Active Distribution Networks", The Institution of Engineering and Technology, London, United Kingdom, 2009.
3. Math H. Bollen , Fainan Hassan, "Integration of Distributed Generation in the Power System", John Wiley &Sons, New Jersey, 2011.
4. Magdi S. Mahmoud, Fouad M. AL-Sunni, "Control and Optimization of Distributed Generation Systems", Springer International Publishing, Switzerland, 2015.
5. NadarajahMithulananthan, Duong Quoc Hung, Kwang Y. Lee, "Intelligent Network Integration of Distributed Renewable Generation", Springer International Publishing, Switzerland, 2017.
6. Ali K., M.N. Marwali, Min Dai, "Integration of Green and Renewable Energy in Electric Power Systems", Wiley and sons, New Jersey, 2010.

MAPPING OF CO'S WITH PO'S

CO	PO					
	1	2	3	4	5	6
1	1	1	2	1	2	1
2	2	2	2	1	3	2
3	2	2	2	1	3	2
4	1	1	2	1	2	1
5	2	2	2	2	3	2
AVG	1.6	1.6	2	1.2	2.4	1.6

PS4071 ENERGY MANAGEMENT AND AUDITING **L T P C**
3 0 0 3

OBJECTIVES:

- To study the concepts behind economic analysis and load management
- To emphasize the energy management of various electrical equipment and metering
- To illustrate the concept of energy management technologies

UNIT I ENERGY SCENARIO 9

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

UNIT II ENERGY COST AND LOAD MANAGEMENT 9

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

UNIT III ENERGY MANAGEMENT 9

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

UNIT IV ENERGY AUDITING 9

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

UNIT V ENERGY EFFICIENT TECHNOLOGIES 9

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

TOTAL : 45 PERIODS

OUTCOMES:

Upon Completion of this course, the students will be able to
CO1: Understand the present energy scenario and role of energy managers.
CO2: Comprehend the Economic Models for cost and load management.
CO3: Configure the Demand side energy management through its control techniques, strategy and planning.
CO4: Understand the process of energy auditing.
CO5: Implement energy conservation aspects in industries.

REFERENCES

1. Barney L. Capehart, Wayne C. Turner, William J. Kennedy, “Guide to Energy Management”, CRC press, Taylor & Francis group, Eighth Edition, 2016.
2. https://prsindia.org/files/bills_acts/bills_parliament/2010/The_Energy_Conservation_Amendment_Bill_2010.pdf
3. Eastop T.D and Croft D.R, “Energy Efficiency for Engineers and Technologists”, Logman Scientific & Technical, 1990.
4. IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities, IEEE, 1996.
5. Amit K. Tyagi, “Handbook on Energy Audits and Management”, TERI, 2003.
6. https://www.eeeguide.com/power-factor-improvement.
7. Anil Kumar, **,Om Prakash,Prashant Singh Chauhan**“Energy Management: Conservation and Audits, CRC Press, 2020.

8. Barney L. Capehart, Wayne C. Turner, William J. Kennedy, “Guide to Energy Management”, CRC press, Taylor & Francis group, Eighth Edition, 2016.
9. S.C. Bhatia and Sarvesh Devraj, “Energy Conservation”, Woodhead Publishing India Pvt. Ltd, 2016.

CO	PO					
	1	2	3	4	5	6
1	2	2	2	-	2	-
2	2	3	2	1	2	1
3	2	2	2	1	2	2
4	1	2	2	3	-	-
5	3	3	2	3	3	3
AVG	2	2.4	2	2	2.25	2

PS4093 SMART GRID L T P C
3 0 0 3

COURSE OBJECTIVES

- To Study about Smart Grid technologies, different smart meters and advanced metering infrastructure.
- To know about the function of smart grid.
- To familiarize the power quality management issues in Smart Grid.
- To familiarize the high performance computing for Smart Grid applications
- To get familiarized with the communication networks for Smart Grid applications

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, Comparison of Micro grid and Smart grid, Present development & International policies in Smart Grid, Smart Grid Initiative for Power Distribution Utility in India – Case Study.

UNIT II SMART GRID TECHNOLOGIES 9
Technology Drivers, Smart Integration of energy resources, Smart substations, Substation Automation, Feeder Automation ,Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control, Distribution systems: DMS, Volt/Var control, Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV) – Grid to Vehicle and Vehicle to Grid charging concepts.

UNIT III 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) & their application for monitoring & protection. Demand side management and demand response programs, Demand pricing and Time of Use, Real Time Pricing, Peak Time Pricing.

UNIT IV POWER QUALITY MANAGEMENT IN SMART GRID 9
Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.

UNIT V HIGH PERFORMANCE COMPUTING FOR SMART GRID APPLICATIONS 9

Architecture and Standards -Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), PLC, Zigbee, GSM, IP based Protocols, Basics of Web Service and CLOUD Computing, Cyber Security for Smart Grid.

TOTAL : 45 PERIODS

COURSE OUTCOME:

Students able to

CO1: Relate with the smart resources, smart meters and other smart devices.

CO2: Explain the function of Smart Grid.

CO3: Experiment the issues of Power Quality in Smart Grid.

CO4: Analyze the performance of Smart Grid.

CO5: Recommend suitable communication networks for smart grid applications

REFERENCES

1. Stuart Borlase ‘Smart Grid: Infrastructure, Technology and Solutions’, CRC Press 2012.
2. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, ‘Smart Grid: Technology and Applications’, Wiley, 2012.
3. Mini S. Thomas, John D McDonald, ‘Power System SCADA and Smart Grids’, CRC Press, 2015
4. Kenneth C.Budka, Jayant G. Deshpande, Marina Thottan, ‘Communication Networks for Smart Grids’, Springer, 2014
5. SMART GRID Fundamentals of Design and Analysis, James Momoh, IEEE press, A John Wiley & Sons, Inc., Publication.

MAPPING O CO’S WITH PO’S

CO	PO					
	1	2	3	4	5	6
1	3	2	-	2	2	2
2	3	-	2	2	-	2
3	2	-	1	-	-	-
4	1	-	-	3	3	1
5	-	2	2	2	2	3
AVG	2.25	2	1.66	2.25	2.3	2

PS4351 HVDC AND FACTS LT P C
3 0 0 3

OBJECTIVES:

- To emphasis the need for FACTS controllers.
- To learn the characteristics, applications and modeling of series and shunt FACTS controllers.
- To analyze the interaction of different FACTS controller and perform control coordination
- To impart knowledge on operation, modelling and control of HVDC link.
- To perform steady state analysis of AC/DC system.

UNIT I INTRODUCTION 9

Review of basics of power transmission networks-control of power flow in AC transmission line- Analysis of uncompensated AC Transmission line- Passive reactive power compensation: Effect of series and shunt compensation at the mid-point of the line on power transfer- Need for FACTS controllers- types of FACTS controllers-Need for HVDC system-MTDC system-Review of basics of LCC and VSC HVDC system.Configurations-Monopolar Asymmetric and Symmetric MMC-HVDC Scheme- Bipolar and Homopolar HVDC Scheme- Multi-Terminal HVDC Configuration- Layout of HVDC system (LCC, VSC)

UNIT II THYRISTOR BASED FACTS CONTROLLERS 9

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 9

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. Modelling of LCC HVDC system and controllers, transformer derating and core saturation instability,Concepts of Power Oscillation Damping Controller, Frequency Controller and Sub synchronous Damping controller in LCC HVDC.

UNIT IV VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS 9

Static synchronous compensator (STATCOM) - Static synchronous series compensator (SSSC) Operation of STATCOM and SSSC-Power flow control with STATCOM and SSSC-Modelling of STATCOM and SSSC for power flow and transient stability studies –operation of Unified and Interline power flow controllers (UPFC) - Modelling of UPFC and IPFC for power flow and transient stability studies-Concepts of Power Oscillation Damping using FACTS controlles

UNIT V VOLTAGE SOURCE CONVERTER BASED HVDC SYSTEM AND CONTROLS 9

Applications VSC based HVDC: Operation, Modelling for steady state and dynamic studies, .Introduction to Modular Multilevel converters- Main circuit design-Converter Operating Principle and Averaged Dynamic Model- Per-Phase Output-Current Control - Arm-Balancing (Internal) Control- Vector Output-Current Control-Higher-Level Control-Modulation and Submodule Energy Balancing- Offshore HVDC integration System Studies -Control and Protection of MMC-HVDC under AC and DC Network Fault Contingencies- Modeling and Simulation of MMC based MTDC Simulation exercises, Steady state, Fault recovery characteristics - Solution of DC load flow-Solution of AC-DC power flow: Sequential and Simultaneous methods.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

1. Learners will be able to refresh on basics of power transmission networks and need for FACTS controllers
2. Ability to design series and shunt compensating devices for power transfer enhancement
3. Learners will understand the significance about different voltage source converter based FACTS controllers
4. Learners will attain knowledge on AC/DC system coordinated control with FACTS and HVDC link
5. Learners will be capable to explore the MMC converter applications FACTS and MTDC system

REFERENCES
1. Mohan Mathur, R., Rajiv. K. Varma, "Thyristor – Based Facts Controllers forElectrical Transmission Systems", IEEE press and John Wiley & Sons, Inc.
2. K.R.Padiyar, "FACTS Controllers in Power Transmission and Distribution", New AgeInternational(P) Ltd., Publishers, New Delhi, Reprint 2008.
3. K.R.Padiyar, "HVDC Power Transmission Systems", New Age International (P) Ltd., New Delhi, 2002.
4. J.Arrillaga, "High Voltage Direct Current Transmission", Peter Pregrinus, London,1983.
5. V.K.Sood, "HVDC and FACTS controllers- Applications of Static Converters in Power System", Kluwer Academic Publishers 2004.

MAPPING OF CO'S WITH PO'S

CO	PO					
	1	2	3	4	5	6
CO1	3	2	1	-	1	-
CO2	1	1	2	-	3	-
CO3	2	-	3	1	1	2
CO4	3	3	1	2	-	1
CO5	2	2	2	-	3	-
AVG	2.2	2	1.8	1.5	2.33	1.5

ET4073 PYTHON PROGRAMMING FOR MACHINE LEARNING **L T P C**
3 0 0 3

COURSE OBJECTIVES:
1. Students will understand and be able to use the basic programming principles such as data types, variable, conditionals, loops, recursion and function calls.
2. Students will learn how to use basic data structures such as List, Dictionary and be able to manipulate text files and images.
3. To make the students familiar with machine learning concepts & techniques.
4. Students will understand the process and will acquire skills necessary to effectively attempt a machine learning problem and implement it using Python.
5. To involve Discussions/ Practice/Exercise onto revising & familiarizing the concepts acquired over the 5 Units of the subject for improved research/employability skills

UNIT I INTRODUCTION TO MACHINE LEARNING AND PYTHON 9

Introduction to Machine Learning: Significance, Advantage and Applications – Categories of Machine Learning – Basic Steps in Machine Learning: Raw Data Collection, Pre-processing, Training a Model, Evaluation of Model, Performance Improvement

Introduction to Python and its significance – Difference between C, C++ and Python Languages; Compiler and Interpreters – Python3 Installation & Running – Basics of Python Programming Syntax: Variable Types, Basic Operators, Reading Input from User – Arrays/List, Dictionary and Set – Conditional Statements – Control Flow and loop control statements

UNIT II PYTHON FUNCTIONS AND PACKAGES 9

File Handling: Reading and Writing Data – Errors and Exceptions Handling – Functions & Modules – Package Handling in Python – Pip Installation & Exploring Functions in python package – Installing the Numpy Library and exploring various operations on Arrays: Indexing, Slicing, Multi-Dimensional Arrays, Joining Numpy Arrays, Array intersection and Difference, Saving and Loading Numpy Arrays – Introduction to SciPy Package & its functions - Introduction to Object Oriented Programming with Python

UNIT III IMPLEMENTATION OF MACHINE LEARNING USING PYTHON 9

Description of Standard Datasets: Coco, ImageNet, MNIST (Handwritten Digits) Dataset, Boston Housing Dataset – Introducing the concepts of Regression – Linear, Polynomial & Logistic Regression with analytical understanding - Introduction to SciPy Package & its functions – Python Application of Linear Regression and Polynomial Regression using SciPy – Interpolation, Overfitting and Underfitting concepts & examples using SciPy

UNIT IV CLASSIFICATION AND CLUSTERING CONCEPTS OF ML 9

Introduction to ML Concepts of Clustering and Classification – Types of Classification Algorithms – Support Vector Machines (SVM) - Decision Tree - Random Forest – Introduction to ML using scikit-learn – Using scikit-learn, Loading a sample dataset, Learning & prediction, interpolation & fitting, Multiclass fitting - Implementation of SVM using Blood Cancer Dataset, Decision Tree using data from csv.

Types of Clustering Algorithms & Techniques – K-means Algorithm, Mean Shift Algorithm & Hierarchical Clustering Algorithm – Introduction to Python Visualization using Matplotlib: Plotting 2-dimensional, 3-dimensional graphs; formatting axis values; plotting multiple rows of data in same graph – Implementation of K-means Algorithm and Mean Shift Algorithm using Python

UNIT V INTRODUCTION TO NEURAL NETWORKS AND EMBEDDED MACHINE LEARNING 9

Introduction to Neural Networks & Significance – Neural Network Architecture – Single Layer Perceptron & Multi-Layer Perceptron (MLP) – Commonly Used Activation Functions - Forward Propagation, Back Propagation, and Epochs – Gradient Descent – Introduction to Tensorflow and Keras ML Python packages – Implementation of MLP Neural Network on Iris Dataset – Introduction to Convolution Neural Networks – Implementation of Digit Classification using MNIST Dataset ML for Embedded Systems: Comparison with conventional ML – Challenges & Methods for Overcoming – TinyML and Tensorflow Lite for Microcontrollers – on-Board AI – ML Edge Devices: Arduino Nano BLE Sense, Google Edge TPU and Intel Movidius

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of this course, the students will have the ability to

CO1: Develop skill in system administration and network programming by learning Python.

CO2: Demonstrating understanding in concepts of Machine Learning and its implementation using Python

CO3: Relate to use Python's highly powerful processing capabilities for primitives, modelling etc

CO4: Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded systems design.

CO5: Apply the concepts acquired over the advanced research/employability skills

CO	PO					
	1	2	3	4	5	6
1	-	-	2	3	3	-
2	3	1	3	-	3	1
3	2	1	2	-	3	3
4	3	2	3	3	3	3
5	-	-	-		3	-
AVg.	2.66	1.33	2.5	3	3	2.33

REFERENCES:

1. Mark Lutz,"LearningPython,Powerful OOPs,O'reilly,2011
2. Zelle, John "M. Python Programming: An Introduction to Computer Science.", Franklin Beedle& Associates, 2003
3. Andreas C. Müller, Sarah Guido, "Introduction to Machine Learning with Python", O'Reilly,2016
4. Sebastian Raschka , VahidMirjalili, "Python Machine Learning - Third Edition", Packt, December 2019

AX4091 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
CO5 – Ensure the good quality of paper at very first-time submission

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.

AX4092 DISASTER MANAGEMENT LT 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

TOTAL : 30 PERIODS

OUTCOMES

CO1: Ability to summarize basics of disaster

CO2: Ability to explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.

CO3: Ability to illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.

CO4: Ability to describe an 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

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.

AX4093	**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.

AX4094	**நற்றமிழ் இலக்கியம்**	**LT P C**
		2 0 0 0

UNIT I சங்க இலக்கியம் 6

1. தமிழின் துவக்க நூல் தொல்காப்பியம்

   – எழுத்து, சொல், பொருள்

2. அகநானூறு (82)

   - இயற்கை இன்னிசை அரங்கம்

3. குறிஞ்சிப் பாட்டின் மலர்க்காட்சி

4. புறநானூறு (95,195)

   - போரை நிறுத்திய ஔவையார்

UNIT II அறநெறித் தமிழ் 6

1. அறநெறி வகுத்த திருவள்ளுவர்

   - அறம் வலியுறுத்தல், அன்புடைமை, ஒப்புரவறிதல், ஈகை, புகழ்

2. பிற அறநூல்கள் - இலக்கிய மருந்து

– ஏலாதி, சிறுபஞ்சமூலம், திரிகடுகம், ஆசாரக்கோவை (தூய்மையை வலியுறுத்தும் நூல்)

UNIT III இரட்டைக் காப்பியங்கள் 6

1. கண்ணகியின் புரட்சி

 - சிலப்பதிகார வழக்குரை காதை

2. சமூகசேவை இலக்கியம் மணிமேகலை

 - சிறைக்கோட்டம் அறக்கோட்டமாகிய காதை

UNIT IV அருள்நெறித் தமிழ் 6

1. சிறுபாணாற்றுப்படை

 - பாரி முல்லைக்குத் தேர் கொடுத்தது, பேகன் மயிலுக்குப் போர்வை கொடுத்தது, அதியமான் ஔவைக்கு நெல்லிக்கனி கொடுத்தது, அரசர் பண்புகள்

2. நற்றிணை

 - அன்னைக்குரிய புன்னை சிறப்பு

3. திருமந்திரம் (617, 618)

 - இயமம் நியமம் விதிகள்

4. தர்மச்சாலையை நிறுவிய வள்ளலார்
5. புறநானூறு

 - சிறுவனே வள்ளலானான்

6. அகநானூறு (4) - வண்டு

 நற்றிணை (11) - நண்டு

 கலித்தொகை (11) - யானை, புறா

 ஐந்திணை 50 (27) - மான்

ஆகியவை பற்றிய செய்திகள்

UNIT V **நவீன தமிழ் இலக்கியம்** **6**

1. உரைநடைத் தமிழ்,
    - தமிழின் முதல் புதினம்,
    - தமிழின் முதல் சிறுகதை,
    - கட்டுரை இலக்கியம்,
    - பயண இலக்கியம்,
    - நாடகம்,
2. நாட்டு விடுதலை போராட்டமும் தமிழ் இலக்கியமும்,
3. சமுதாய விடுதலையும் தமிழ் இலக்கியமும்,
4. பெண் விடுதலையும் விளிம்பு நிலையினரின் மேம்பாட்டில் தமிழ் இலக்கியமும்,
5. அறிவியல் தமிழ்,
6. இணையத்தில் தமிழ்,
7. சுற்றுச்சூழல் மேம்பாட்டில் தமிழ் இலக்கியம்.

<u>தமிழ் இலக்கிய வெளியீடுகள் / புத்தகங்கள்</u>

1. தமிழ் இணைய கல்விக்கழகம் (Tamil Virtual University)

    - www.tamilvu.org

2. தமிழ் விக்கிப்பீடியா (Tamil Wikipedia)

-https://ta.wikipedia.org

3. தர்மபுர ஆதீன வெளியீடு

4. வாழ்வியல் களஞ்சியம்

    - தமிழ்ப் பல்கலைக்கழகம், தஞ்சாவூர்

5. தமிழ்கலைக் களஞ்சியம்

    - தமிழ் வளர்ச்சித் துறை (thamilvalarchithurai.com)

6. அறிவியல் களஞ்சியம்

- தமிழ்ப் பல்கலைக்கழகம், தஞ்சாவூர்

TOTAL: 30 PERIODS