FRANCIS XAVIER ENGINEERING COLLEGE

AUTONOMOUS INSTITUTION

ACCREDITED BY NBA

ISO 9001:2015 Certified | DST-FIST Supported Institution

Recognized under Section 2(f) & 12(B) of the UGC Act, 1956

Vannarpettai, Tirunelveli - 627003, Tamil Nadu

CURRICULUM & SYLLABI

M. E - Power Electronics & Drives (Regulation 2019)

VISION

"To be a Centre of Excellence for Technology transformation in the field of Electrical and Electronics Engineering"

MISSION

1. To empower the vibrant young leaders with technical skills and knowledge in the field of technology
2. To facilitate the industries to adopt effective solutions in the field of Electrical and Electronics Engineering through consultancy
3. To transform technology for rural needs.

FRANCIS XAVIER ENGINEERING COLLEGE

TIRUNELVELI

PROGRAM EDUCATIONAL OBJECTIVES (PEOS)

PEO1: Graduates of this program will have technical knowledge, skills and ability to design, develop and test power electronic converters and drives using advanced tools.

PEO2: Graduates of this program will have skills and knowledge in the field of power electronics and drives to work in the design, fabrication industries and research organizations.

PEO3: Graduates of this program will show confidence and exhibit self-learning capability and demonstrate a pursuit in life-long learning through higher studies and research.

PEO4: Graduates of this program will show involvement and willingness in assuming responsibility in societal and environmental causes.

PROGRAM OUTCOMES (POs)

PO1: Acquire sound **knowledge** in power electronics and drives.

PO2: Analyze power electronics and drives related engineering **problems** and synthesize the information for conducting high level of research.

PO3: Think widely to offer creative and **innovative solutions** of engineering problems that are inconformity with social and environmental factors.

PO4: Extract the new methodologies by carrying out the literature survey, proper design and **conduction of experiments**, interpret and analyze the data to arrive at meaningful research methodologies in power electronics and drives.

PO5: Learn and apply **modern engineering** and IT tools to solve complex engineering problems related to power converters and electric drives.

PO6: Ability to form, understand group dynamics and work in **inter-disciplinary groups** in order to achieve the goal.

PO7: Ability to **communicate** effectively in appropriate technical forums and understand the concepts and ideas to prepare reports, to make effective presentations.

PO8: Ability to update knowledge and skills through **lifelong learning** to keep abreast with the technological developments.

PO9: Follow the professional and research **ethics**, comprehend the impact of research and responsibility in order to contribute to the society.

PO10: Understand the leadership principles and subject oneself to introspection and take voluntary remedial measures for effective **professional practice** in the field of power electronics and electric drives.

MAPPING OF PROGRAMME EDUCATIONAL OBJECTIVES WITH PROGRAMME OUTCOMES

PEOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
PEO1	**X**	**X**	**X**	**X**	**X**		**X**	**X**		
PEO2	**X**			**X**	**X**	**X**	**X**	**X**	**X**	**X**
PEO3				**X**	**X**	**X**		**X**	**X**	
PEO4	**X**	**X**	**X**						**X**	**X**

FRANCIS XAVIER ENGINEERING COLLEGE, TIRUNELVELI

M. E –POWER ELECTRONICS AND DRIVES
REGULATIONS - 2019
CHOICE BASED CREDIT SYSTEM
I TO IV SEMESTERS CURRICULUM & SYLLABI

FIRST SEMESTER							
Code No.	**Course**	**Category**	**L**	**T**	**P**	**C**	**H**
19MA1253	Applied Mathematics for Electrical Engineers	BS	3	1	0	4	4
19PE1601	Advanced Power Semiconductor Devices	PC	3	0	0	3	3
19PE1602	Analysis and Design of Power Converters and Inverters	PC	3	0	0	3	3
19PE1603	Modelling and Analysis of Electrical Machines	PC	3	0	0	3	3
19PE1604	Solar and Energy Storage Systems	PC	3	0	0	3	3
19PE1605	System Theory	PC	3	1	0	4	4
19PE1611	Power Electronics Circuits Lab	PC	0	0	4	2	4
		TOTAL	**18**	**2**	**4**	**22**	**24**

SECOND SEMESTER							
Code No.	**Course**	**Category**	**L**	**T**	**P**	**C**	**H**
19PE2601	Solid State DC Drives	PC	3	0	0	3	3
19PE2602	Solid State AC Drives	PC	3	0	0	3	3
19PE2603	Special Machines and Controllers	PC	3	0	0	3	3
	Professional Elective I	PE	3	0	0	3	3
	Professional Elective II	PE	3	0	0	3	3
	Professional Elective III	PE	3	0	0	3	3
19PE2611	Electrical Drives Laboratory	PC	0	0	4	2	4
19PE2911	Mini Project	EEC	0	0	4	2	4
		TOTAL	**18**	**0**	**8**	**22**	**26**

THIRD SEMESTER							
Code No.	**Course**	**Category**	**L**	**T**	**P**	**C**	**H**
	Professional Elective IV	PE	3	0	0	3	3
	Professional Elective V	PE	3	0	0	3	3
	Professional Elective VI	PE	3	0	0	3	3
19PE3911	Project Work Phase I	EEC	0	0	12	6	12
		TOTAL	**09**	**0**	**12**	**15**	**21**

FOURTH SEMESTER							
Code No.	**Course**	**Category**	**L**	**T**	**P**	**C**	**H**
19PE4911	Project Work Phase II	EEC	0	0	24	12	24
		TOTAL	**0**	**0**	**24**	**12**	**24**

Total Credits :71

Code No.	Course	L	T	P	C
PROFESSIONAL ELECTIVES					
PROFESSIONAL ELECTIVE I- SEMESTER II					
19PE2701	Power Quality	3	0	0	3
19PE2702	Electromagnetic Field Computation and Modelling	3	0	0	3
19PE2703	Control System Design for Power Electronics	3	0	0	3
19PE2704	Soft Computing Techniques	3	0	0	3
PROFESSIONAL ELECTIVE II&III - SEMESTER II					
19PE2705	Flexible AC Transmission Systems	3	0	0	3
19PE2706	Modern Rectifiers and Resonant Converters	3	0	0	3
19PE2707	Electromagnetic Interference and Compatibility	3	0	0	3
19PE2708	Power Electronics for Renewable Energy Systems	3	0	0	3
19PE2709	Distributed Generation and Micro-grid	3	0	0	3
19PE2710	Analog and Digital Controllers	3	0	0	3
PROFESSIONAL ELECTIVE IV, V & VI - SEMESTER III					
19PE3701	High Voltage Direct Current Transmission	3	0	0	3
19PE3702	Non Linear Control	3	0	0	3
19PE3703	Wind Energy Conversion Systems	3	0	0	3
19PE3704	Optimization Techniques	3	0	0	3
19PE3705	Electric and Hybrid Vehicles	3	0	0	3
19PE3706	Non Linear Dynamics for Power Electronics Circuits	3	0	0	3
19PE3707	Smart Grid	3	0	0	3
19PE3708	MEMS Technology	3	0	0	3
19PE3709	Robotics and Control	3	0	0	3

19MA1253	APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERS	L	T	P	C
		3	1	0	4

OBJECTIVES :

1. The main objective of this course is to demonstrate various analytical skills in applied mathematics and extensive experience with the tactics of problem solving and logical thinking applicable for the students of electrical engineering.
2. This course also will help the students to identify, formulate, abstract, and solve problems in electrical engineering using mathematical tools from a variety of mathematical areas, including matrix theory, calculus of variations, probability, linear programming and Fourier series.

PRE-REQISITE:

- Engineering Mathematics

UNIT I MATRIX THEORY 12

Cholesky decomposition-Generalized Eigenvectors-Canonical basis-QR Factorization-Least squares method-Singular value decomposition

UNIT II CALCULUS OF VARIATIONS 12

Concept of variation and its properties–Euler's equation–Functional dependant on first and higher order derivatives–Functionals dependant on functions of several independent variables–Variational problems with moving boundaries–Isoperimetric problems-Direct methods : Ritz and Kantorovich methods.

UNIT III PROBABILITY AND RANDOM VARIABLES 12

Probability–Axioms of probability–Conditional probability–Baye's theorem-Random variables-Probability function–Moments–Moment generating functions and their properties–Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions–Function of a random variable.

UNIT IV LINEAR PROGRAMMING 12

Formulation–Graphical solution–Simplex method–Big M method-Two phase method-Transportation and Assignment models.

UNIT V FOURIER SERIES **12**

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

TOTAL PERIODS : 60

REFERENCES :

1. Andrews L.C. and Phillips R.L., "Mathematical Techniques for Engineers and Scientists",Prentice Hall of India Pvt. Ltd., New Delhi, 2005.
2. Bronson, R. "Matrix Operation", Schaum's outline series, 2ndEdition, McGraw Hill, 2011.
3. Elsgolc, L. D. "Calculus of Variations", Dover Publications, New York, 2007.
4. Johnson, R.A., Miller, I and Freund J., "Miller and Freund's Probability and Statistics forEngineers", Pearson Education, Asia, 8thEdition, 2015.
5. O'Neil, P.V., "Advanced Engineering Mathematics", Thomson Asia Pvt. Ltd., Singapore, 2003.
6. Taha, H.A., "Operations Research, An Introduction",9thEdition, Pearson education, NewDelhi, 2016.

COURSE OUTCOMES:

CO101.1	Apply various methods in matrix theory to solve system of linear equations.
CO101.2	Maximizing and minimizing the functional that occur in electrical engineering discipline.
CO101.3	Computation of probability and moments, standard distributions of discrete and continuous random variables and functions of a random variable.
CO101.4	Could develop a fundamental understanding of linear programming models, able to develop a linear programming model from problem description, apply the simple method for solving linear programming problems.
CO101.5	Fourier series analysis and its uses in representing the power signals

POs Vs COs MAPPING:

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO101.1	2		2							2
CO101.2	2		2							2
CO101.3	2		2							2
CO101.4	2		2							2
CO101.5	2		2							2

1 ➐ Low 2 ➐ Medium 3 ➐ High

19PE1601 ADVANCED POWER SEMICONDUCTOR DEVICES **L T P C**

3 0 0 3

OBJECTIVES:

1. To impart knowledge on semiconductor switches, Electromagnetic interference and Power diodes.
2. To impart knowledge on Current controlled devices.
3. To impart knowledge on Voltage controlled devices.
4. To impart knowledge on Firing circuits.
5. To impart knowledge on Thermal protection of Power devices.

PRE-REQISITE:

- Power Electronics
- Solid State Drives.

UNIT I INTRODUCTION 9

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

UNIT II CURRENT CONTROLLED DEVICES 9

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

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- Integrated gate commutated thyristor (IGCT) - Comparison of all power devices.

UNIT IV FIRING AND PROTECTING CIRCUITS 9

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

UNIT 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

REFERENCES

1. B.W Williams ‘Power Electronics Circuit Devices and Applications’..
2. Rashid M.H., " Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Third Edition, New Delhi, 2004
3. MD Singh and K.B Khanchandani, “Power Electronics”, Tata McGraw Hill, 2001.
4. Mohan, Undeland and Robins, “Power Electronics – Concepts, applications and Design, John Wiley and Sons, Singapore, 2000.
5. Joseph Vithayathil, Power Electronics: Principles and Applications, Delhi, Tata McGraw- Hill, 2010.
6. Ned Mohan Tore. M. Undel and, William. P. Robbins, ‘Power Electronics: Converters, Applications and Design’, John Wiley and sons, third edition, 2003.

WEBRESOURCE(S):

- https://nptel.ac.in/courses/108/102/108102145/

COURSE OUTCOMES:

CO102.1 Ability to understand semiconductor switches, Electromagnetic interference and Power diodes.

CO102.2 Ability to Analyze Current controlled Switches Design

CO102.3 Ability to Analyze Voltage controlled Switches Design

CO102.4 Ability to design of protection circuits and control circuits

CO102.5 Ability to design Thermal protection for power devices.

POs Vs COs MAPPING:

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO102.1	1			1						1
CO102.2	1	2		2						2
CO102.3	2	3		3						2
CO102.4	2		2							3
CO102.5	3		3							3

1 ➔ Low 2 ➔ Medium 3 ➔ High

		L	T	P	C
19PE1602	**ANALYSIS AND DESIGN OF POWER CONVERTERS AND INVERTERS**				
		3	**0**	**0**	**3**

OBJECTIVES:

1. To determine the operation and characteristics of Power converters.
2. To introduce the design of power converter components.
3. To comprehend the concepts of resonant converters and AC-AC power converters.
4. To analyse and comprehend the various types of inverters.
5. To impart knowledge on multilevel inverters and Boost inverters.

PRE-REQUISITE:

- Power Electronics
- Solid State Drives
- Power Electronics For Renewable Energy Sources.

UNIT I POWER CONVERTERS 9

single-phase and Three phase full converter and semi converter (RL,RLE load)- Dual converter – PWM rectifiers. Operation and analysis of Buck, Boost, Buck-Boost, Cuk & SEPIC – under continuous and discontinuous operation – Isolated converters: basic operation of Fly back, Forward and Push-pull topologies.

UNIT II DESIGN OF POWER CONVERTER COMPONENTS 9

Introduction to magnetic materials- hard and soft magnetic materials –types of cores , copper windings – Design of transformer –Inductor design equations –Examples of inductor design for buck/fly back converter-selection of output filter capacitors – selection of ratings for devices – input filter design.

UNIT III RESONANT DC-DC CONVERTERS& AC-AC CONVERTERS 9

Resonant switch converters – operation and analysis of ZVS, ZCS converters comparison of ZCS/ZVS Introduction to ZVT/ZCT PWM converters. Single phase ac voltage controller – analysis with R & RL load – Three phase ac voltage controller – principle of operation of cyclo converter – single phase and three phase cyclo converters – Introduction to matrix converters.

UNIT IV VOLTAGE SOURCE AND CURRENT SOURCE INVERTERS 9

Principle of operation of single phase full bridge inverters, Three phase Inverter: 180 degree and 120 degree conduction mode inverters – voltage control of inverters : Space vector modulation techniques .Operation of six-step thyristor inverter load – commutated inverters – Auto sequential current source inverter (ASCI), PWM techniques for current source inverters.

UNIT V MULTILEVEL INVERTERS , BOOST & RESONANT INVERTERS 9

Multilevel concept – diode clamped – flying capacitor – cascade type multilevel inverters -Comparison of multilevel inverters .Series and parallel resonant inverters - voltage control of resonant inverters – Class Eresonant inverter – resonant DC - link inverters

TOTAL : 45 PERIODS

TEXT BOOKS:

1. Ned Mohan,T.MUndeland and W.P Robbin, “Power Electronics: converters, Application and design” John Wiley and sons. Wiley India edition, 2006.
2. Rashid M.H., “Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Third Edition, New Delhi, 2004.
3. P.C. Sen, “Modern Power Electronics”, Wheeler Publishing Co, First Edition, New Delhi, 1998.
4. P.S.Bimbra, “Power Electronics”, Khanna Publishers, Eleventh Edition, 2003.
5. Simon Ang, Alejandro Oliva, “Power-Switching Converters, Second Edition, CRC Press, Taylor & Francis Group, 2010.
6. V.Ramanarayanan, “Course material on Switched mode power conversion”, 2007.
7. Alex Van den Bossche and VencislavCekovValchev, “Inductors andTransformersforPowerElectronics”, CRC Press, Taylor & Francis Group, 2005.
8. W. G. Hurley and W. H.Wolfle, “Transformers and Inductors for Power Electronics Theory, Design and Applications”, 2013 John Wiley & Sons Ltd.
9. Marian.K.Kazimierczuk and DariuszCzarkowski, “Resonant Power Converters”, John Wiley & Sons limited, 2011.
10. Jai P.Agrawal, “Power Electronics Systems”, Pearson Education, Second Edition, 2002
11. Bimal K.Bose “Modern Power Electronics and AC Drives”, Pearson Education, Second Edition, 2003.
12. Philip T. krein, “Elements of Power Electronics” Oxford University Press -1998.

WEB RESOURCES:

1. https://www.powerelectronics.com/technologies/dc-dc-converters/article/21861281/buck converter-design-demystified
2. https://www.youtube.com/watch?v=LwPJi3jyfw0
3. http://dese.iisc.ac.in/design-of-power-converters/

COURSE OUTCOMES:

CO103.1	Analyze various power converters
CO103.2	Develop improved power converters for any stringent application requirements.
CO103.3	Design resonant and ac-ac converters.
CO103.4	Develop various types of inverter.
CO103.5	Design Multilevel Inverters and boot inverters

POs Vs COs MAPPING:

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO103.1	**3**	**3**								**3**
CO103.2	**3**		**2**							**3**
CO103.3	**3**		**2**							**3**
CO103.4	**3**		**2**							**3**
CO103.5	**3**		**2**							**3**

13. 1 ➐ Low 2 ➐ Medium 3 ➐ High

19PE1603	**MODELING AND ANALYSIS OF ELECTRICAL MACHINES**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVCES:

1. To provide knowledge about the fundamentals of magnetic circuits, energy, force and torque of multi-excited systems.
2. To analyze the steady state and dynamic state operation of DC machine through mathematical modelling and simulation in digital computer.
3. To provide the knowledge of theory of transformation of three phase variables to two phase variables.
4. To analyze the steady state and dynamic state operation of three-phase induction machines using transformation theory based mathematical modeling and digital computer simulation.
5. To analyze the steady state and dynamic state operation of three-phase synchronous machines using transformation theory based mathematical modeling and digital computer simulation.

PRE-REQISITE:

- Electrical Machines

UNIT I PRINCIPLES OF ELECTROMAGNETIC ENERGY CONVERSION 9

Magnetic circuits, permanent magnet, stored magnetic energy, co-energy - force and torque in singly and doubly excited systems – machine windings and air gap mmf - winding inductances and voltage equations.

UNIT II DC MACHINES 9

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

UNIT III REFERENCE FRAME THEORY 9

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

UNIT IV INDUCTION MACHINES 9

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

UNIT V SYNCHRONOUS MACHINES 9

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

TOTAL: 45 PERIODS

REFERENCES

1. Paul C.Krause, Oleg Wasyzczuk, Scott S, Sudhoff, "Analysis of Electric Machinery and Drive Systems", John Wiley, Second Edition, 2010.
2. P S Bimbhra, "Generalized Theory of Electrical Machines", Khanna Publishers, 2008.
3. A.E, Fitzgerald, Charles Kingsley, Jr, and Stephan D, Umanx, " Electric Machinery",Tata McGraw Hill, 5th Edition, 1992
4. R. Krishnan, Electric Motor & Drives: Modeling, Analysis and Control, New Delhi, Prentice Hall of India, 2001.

WEB SOURCES:

1. https://nptel.ac.in/content/syllabus_pdf/108106023.pdf
2. https://nptel.ac.in/courses/108106023/

COURSE OUTCOMES:

CO104.1	Ability to understand the various electrical parameters in mathematical form
CO104.2	Ability to understand the different types of reference frame theories and transformation relationships.
CO104.3	Ability to find the electrical machine equivalent circuit parameters and modeling of electrical machines.
CO104.4	Ability to know about the equivalent circuit parameters and modeling of Induction machines
CO104.5	Ability to know about the equivalent circuit parameters and modeling of Synchronous machines

POs Vs COs MAPPING:

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO104.1	2	1	2					2		
CO104.2	2	1	2					2		
CO104.3	2	1	2					2		
CO104.4	2	1	2					2		
CO104.5	2	1	2					2		

5. 1 → Low 2 → Medium 3 → High

19PE1604	SOLAR AND ENERGY STORAGE SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVCES:

- To Study about solar modules and PV system design and their applications
- To Deal with grid connected PV systems
- To Discuss about different energy storage systems

PRE-REQISITE:

- Power Electronics
- Solid State Drive

UNIT I INTRODUCTION 9

Characteristics of sunlight – semiconductors and P-N junctions –behaviour of solar cells – cell properties – PV cell interconnection

UNIT II STAND ALONE PV SYSTEM 9

Solar modules – storage systems – power conditioning and regulation - MPPT- protection – stand alone PV systems design – sizing

UNIT III GRID CONNECTED PV SYSTEMS 9

PV systems in buildings – design issues for central power stations – safety – Economic aspect – Efficiency and performance - International PV programs

UNIT IV ENERGY STORAGE SYSTEMS 9

Impact of intermittent generation – Battery energy storage – solar thermal energy storage – pumped hydroelectric energy storage

UNIT V APPLICATIONS 9

Water pumping – battery chargers – solar car – direct-drive applications –Space – Telecommunications.

TOTAL : 45 PERIODS

REFERENCES

1. Solanki C.S., "Solar Photovoltaics: Fundamentals, Technologies And Applications", PHI Learning Pvt. Ltd.,2015.
2. Stuart R.Wenham, Martin A.Green, Muriel E. Watt and Richard Corkish, "AppliedPhotovoltaics", 2007,Earthscan, UK.
3. Eduardo Lorenzo G. Araujo, "Solar electricity engineering of photovoltaic systems", Progensa,1994.
4. Frank S. Barnes & Jonah G. Levine, "Large Energy storage Systems Handbook", CRC Press, 2011.
5. McNeils, Frenkel, Desai, "Solar & Wind Energy Technologies", Wiley Eastern, 1990 S.P. Sukhatme , "Solar Energy", Tata McGraw Hill,1987.

WEB SOURCE(S):

1. https://nptel.ac.in/courses/112105051/

2. https://www.nationalgeographic.com/environment/energy/reference/renewable- energy/

COURSE OUTCOMES:

CO105.1	Students will develop more understanding on solar energy storage systems
CO105.2	Students will develop basic knowledge on standalone PV system
CO105.3	Students will understand the issues in grid connected PV systems
CO105.4	Students will study about the modeling of different energy storage systems and their performances
CO105.5	Students will attain more on different applications of solar energy

POs Vs COs MAPPING:

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO105.1	3	1	1			2	2		1	3
CO105.2	3	1	1			2	2		1	3
CO105.3	3	1	1			2	2		1	3
CO105.4	3	1	1			2	2		1	3
CO105.5	3	1	1			2	2		1	3

1 ➐ Low 2 ➐ Medium 3 ➐ High

19PE1605	**SYSTEM THEORY**	**L**	**T**	**P**	**C**
		3	**1**	**0**	**4**

OBJECTIVCES:

1. To understand the fundamentals of physical systems in terms of its linear and nonlinear models.
2. To educate on representing systems in state variable form
3. To educate on solving linear and non-linear state equations
4. To exploit the properties of linear systems such as controllability and observability
5. To educate on stability analysis of systems using Lyapunov's theory
6. To educate on modal concepts and design of state and output feedback controllers and estimators

PRE-REQISITE:

- Control System

UNIT I STATE VARIABLE REPRESENTATION 9

Introduction-Concept of State-State 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 STABILITY ANALYSIS OF LINEAR SYSTEMS 9

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

UNIT IV STATE FEEDBACK CONTROL AND STATE ESTIMATOR 9

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

UNIT V LYAPUNOV STABILTY ANALYSIS 9

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

TOTAL : 45+15 = 60 PERIODS

TEXT BOOKS:

1. M. Gopal, "Modern Control System Theory", New Age International, 2005.
2. K. Ogatta, "Modern Control Engineering", PHI, 2002.
3. John S. Bay, "Fundamentals of Linear State Space Systems", McGraw-Hill, 1999.
4. D. Roy Choudhury, "Modern Control Systems", New Age International, 2005.
5. John J. D'Azzo, C. H. Houpis and S. N. Sheldon, "Linear Control System Analysis and Design with MATLAB", Taylor Francis, 2003.
6. Z. Bubnicki, "Modern Control Theory", Springer, 2005.
7. C.T. Chen, "Linear Systems Theory and Design'' Oxford University Press, 3rd Edition,1999.
8. M. Vidyasagar, "Nonlinear Systems Analysis', 2nd edition, Prentice Hall, Englewood Cliffs, New Jersey.

WEB SOURCE(S):

1. https://nptel.ac.in/courses/108106150/
2. https://nptel.ac.in/courses/108101037/

COURSE OUTCOMES:

CO106.1	Ability to represent the time-invariant systems in state space form.
CO106.2	Ability to design state feedback controller and state observers
CO106.3	Ability to classify singular points and construct phase trajectory using delta and isocline methods.
CO106.4	Use the techniques such as describing function, Lyapunov Stability, Popov's Stability Criterion and Circle Criterion to assess the stability of certain class of non-linear system.
CO106.5	To analyze, whether the system is stabilizable, controllable, observable and detectable.

POs Vs COs MAPPING:

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO106.1	2	3	3	2					1	
CO106.2	2	3	3	2					1	
CO106.3	2	3	3	2					1	
CO106.4	2	3	3	2					1	
CO106.5	2	3	3	2					1	

1 ➐ Low 2 ➐ Medium 3 ➐ High

19PE1611	POWER ELECTRONICS CIRCUITS LAB	L	T	P	C
		0	0	4	2

OBJECTIVCES:

1. To provide an insight on the switching behaviours of power electronic switches
2. To make the students familiar with the digital tools used in generation of gate pulses for the power electronic switches
3. To make the students capable of implementing analog interfacing as well as control circuits used in a closed-loop control for power electronic system
4. To make the students acquire knowledge on mathematical modeling of power electronic circuits and implementing the same using simulation tools
5. To facilitate the students to design and fabricate a power converter circuits at appreciable voltage/power levels
6. To develop skills on PCB design and fabrication among the students

PRE-REQISITE:

- Power electronics
- Solid state drives
- Power electronics laboratory

LIST OF EXPERIMENTS

1. Study of switching characteristics of Power electronic switches with and without Snubber (i) IGBT (ii) MOSFET
2. Modeling and system simulation of basic electric circuits using MATLABSIMULINK/SCILAB
3. DC source fed resistive load and Resistive-inductive load
4. DC source fed RLC load for different damping conditions
5. DC source fed DC motor load
6. Modeling and System simulation of basic power electronic circuits using MATLAB-SIMULINK/SCILAB
7. AC Source with Single Diode fed Resistive and Resistive-Inductive Load
8. AC source with Single SCR fed Resistive and Resistive-Inductive Load
9. Modeling and System Simulation of SCR based full converter with different types of load using MATLAB-Simulink/SCILAB
10. Full converter fed resistive load
11. Full converter fed Resistive-Back Emf (RE) load at different firing angles
12. Full Converter fed Resistive-Inductive Load at different firing angles
13. Full converter fed DC motor load at different firing angles
14. Circuit Simulation of Voltage Source Inverter and study of spectrum analysis with and without filter using MATLAB/SCILAB
15. Single phase square wave inverter
16. Three phase sine PWM inverter
17. Design of Driver Circuit using IR2110
18. Measurement of Efficiency at different duty cycle with a resistive load
19. Measurement of Efficiency at different duty cycle with a resistive-inductive load

TOTAL PERIODS: 30

WEB SOURCE(S):

1. https://www.srmist.edu.in/content/power-electronics-lab
2. http://www.uoh.edu.sa/en/Subgates/Faculties/CM/Departments/Electrical/Pages/electricmachinelab.aspx

COURSE OUTCOMES:

CO107.1	Comprehensive understanding on the switching behavior of Power Electronic Switches
CO107.2	Comprehensive understanding on mathematical modeling of power electronic system and ability to implement the same using simulation tools
CO107.3	Ability of the student to use microcontroller and its associated IDE for power electronic applications
CO107.4	Ability of the student to design and implement analog circuits for Power electronic control applications
CO107.5	Ability to design and fabricate a power converter circuit at an reasonable power level

POs Vs COs MAPPING:

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO107.1	3	2	1	3	1			2		
CO107.2	3	2	1	3	1			2		
CO107.3	3	2	1	3	1			2		
CO107.4	3	2	1	3	1			2		
CO107.5	3	2	1	3	1			2		

1 ❼ Low 2 ❼ Medium 3 ❼ High

19PE2601	**SOLID STATE DC DRIVES**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES:

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

PRE-REQISITE:

- Power Electronics
- Electrical DC Machines

UNIT I DC MOTORS FUNDAMENTALS AND MECHANICAL SYSTEMS 9

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

UNIT II CONVERTER CONTROL 9

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

UNIT III CHOPPER CONTROL 9

Introduction to time ratio control and frequency modulation; Class A, B, C, D and E chopper controlled DC motor – performance analysis, multi-quadrant control – Chopper based implementation of braking schemes; Multi-phase chopper; Related problems.

UNIT IV CLOSED LOOP CONTROL 9

Modelling 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 d.c drive.

UNIT V DIGITAL CONTROL OF D.C DRIVE 9

Phase Locked Loop and micro-computer control of DC drives – Program flow chart for constant horse power and load disturbed operations; Speed detection and current sensing circuits.

TOTAL : 45 PERIODS

REFERENCES

1. Gopal K Dubey, “Power Semiconductor controlled Drives”, Prentice Hall Inc., New Yersy, 1989.
2. R.Krishnan, “Electric Motor Drives – Modeling, Analysis and Control”, Prentice-Hall of India Pvt. Ltd., New Delhi, 2010.
3. Gobal K.Dubey, “Fundamentals of Electrical Drives”, Narosal Publishing House, New Delhi, Second Edition ,2009
4. Vedam Subramanyam, “Electric Drives – Concepts and Applications”, Tata McGraw-Hill publishing company Ltd., New Delhi, 2002.
5. P.C Sen “Thyristor DC Drives”, John wiely and sons, New York, 1981.

WEB SOURCE(S):

https://mitpress.mit.edu/books/solid-state-dc-motor-drives
https://www.scribd.com/document/253784176/Solid-State-Dc-Drives-Part1-PDF

COURSE OUTCOMES:

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

CO201.1	Will be able to understand the basic concept of fundamentals and mechanism of drives.
CO201.2	Will acquire knowledge about the operation of the converter fed DC drive.
CO201.3	Will able understand the concepts of chopper fed DC drive.
CO201.4	Will get expertise in design the current and speed controllers for a closed loop solid state DC motor drive.
CO201.5	Will be able to implement of control algorithms using microcontrollers and phase locked loop

POs Vs COs MAPPING:

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO201.1	3	2		2	2			2		
CO201.2	3	2		2	2			2		
CO201.3	3	2		2	2			2		
CO201.4	3	2		2	2			2		
CO201.5	3	2		2	2			2		

1 ➐ Low 2 ➐ Medium 3 ➐ High

19PE2602	SOLID STATE AC DRIVES	L	T	P	C
		3	0	0	3

OBJECTIVES:

1. To understand various operating regions of the induction motor drives.
2. To study and analyze the operation of VSI & CSI fed induction motor control.
3. To understand the speed control of induction motor drive from the rotor side.
4. To understand the field oriented control of induction machine.
5. To understand the control of synchronous motor drives.

PRE-REQISITE:

- Power Electronics
- AC Machines

UNIT I INTRODUCTION TO INDUCTION MOTORS 9

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

UNIT II VSI AND CSI FED INDUCTION MOTOR CONTROL 9

AC voltage controller circuit – six step inverter voltage control-closed loop variable frequency PWM inverter with dynamic braking-CSI fed IM variable frequency drives comparison

UNIT III ROTOR CONTROLLED INDUCTION MOTOR DRIVES 9

Static rotor resistance control – injection of voltage in the rotor circuit – static scherbius drives – power factor considerations – modified Kramer drives

UNIT IV FIELD ORIENTED CONTROL 9

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

UNIT V SYNCHRONOUS MOTOR DRIVES 9

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

TOTAL: 45 PERIODS

REFERENCES

1. Bimal K Bose, "Modern Power Electronics and AC Drives", Pearson Education Asia 2002.
2. Vedam Subramanyam, "Electric Drives – Concepts and Applications", Tata McGraw Hill, 1994.
3. Gopal K Dubey, "Power Semiconductor controlled Drives", Prentice Hall Inc., New Yersy, 1989.
4. R.Krishnan, "Electric Motor Drives – Modeling, Analysis and Control", Prentice-Hall of India Pvt. Ltd., New Delhi, 2003.
5. W.Leonhard, "Control of Electrical Drives", Narosa Publishing House, 1992.
6. Murphy J.M.D and Turnbull, "Thyristor Control of AC Motors", Pergamon Press, Oxford, 1988.
7.

WEB SOURCE(S):

1. https://mitpress.mit.edu/books/solid-state-dc-motor-drives
2. https://www.scribd.com/document/253784176/Solid-State-Dc-Drives-Part1-PDF

COURSE OUTCOMES:

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

CO202.1	Will be able to understand the basic concept of induction motors.
CO202.2	Will acquire knowledge about the operation of VSI & CSI fed induction motor drive.
CO202.3	Will able understand the concepts of rotor controlled drive.
CO204.4	Will get field oriented control of induction machine
CO204.5	Will be able to understand the concepts of synchronous motor.

POs Vs COs MAPPING:

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO202.1	3	2		2	2			2		
CO202.2	3	2		2	2			2		
CO202.3	3	2		2	2			2		
CO204.4	3	2		2	2			2		
CO204.5	3	2		2	2			2		

1 → Low 2 → Medium 3 → High

19PE2603	SPECIAL MACHINES AND CONTROLLERS	L	T	P	C
		3	0	0	3

OBJECTIVES:

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

PRE-REQISITE:

- Electrical Machines-I
- Electrical Machines -II

UNIT I PERMANENT MAGNET BRUSHLESS DC MOTORS 9

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

UNIT II PERMANENT MAGNET SYNCHROUNOUS MOTORS 9

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

UNIT III SWITCHED RELUCTANCE MOTORS 9

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

UNIT IV STEPPER MOTORS 9

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

UNIT V OTHER SPECIAL MACHINES 9

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

TOTAL : 45 PERIODS

REFERENCES:

1. T.J.E. Miller, 'Brushless magnet and Reluctance motor drives', Claredon press, London, 1989.
2. R.Krishnan, 'Switched Reluctance motor drives', CRC press, 2001.
3. T.Kenjo, 'Stepping motors and their microprocessor controls', Oxford University press, New Delhi, 2000.
4. T.Kenjo and S.Nagamori, 'Permanent magnet and Brushless DC motors', Clarendon press, London, 1988.
5. R.Krishnan, 'Electric motor drives' , Prentice hall of India,2002.
6. D.P.Kothari and I.J.Nagrath, ' Electric machines', Tata Mc Graw hill publishing company, New Delhi, Third Edition, 2004.
7. Irving L.Kosow, "Electric Machinery and Transformers" Pearson Education, Second Edition, 2007.

WEB SOURCE(S):

1. https://www.brainkart.com/subject/Special-Electrical-Machines_185/
2. https://nptel.ac.in/courses/108105131/

COURSE OUTCOMES(S):

CO203.1	Ability to understand the Characteristics of Permanent magnet Brushless DC motors.
CO203.2	Ability to understanding the concept of Permanent magnet Synchronous DC motors.
CO203.3	Ability to understanding the Concept of Switched Reluctance motors.
CO203.4	Ability to understanding the Concept of Stepper motors.
CO203.5	Ability to select the various types of special motor for a certain job Conditions.

POs Vs COs MAPPING:

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO203.1	3	2			2			2		1
CO203.2	3	2			2			2		1
CO203.3	3	2	1		2			2		1
CO203.4	3	2	1		2			2		1
CO203.5	3	2			2			2		1

8. **1 ➐ Low 2 ➐ Medium 3 ➐ High**

19PE2611 ELECTRICAL DRIVES LABORATORY L T P C

0 0 4 2

OBJECTIVES:

1. To design and analyze the various DC and AC drives.
2. To generate the firing pulses for converters and inverters using digital processors.
3. Design of controllers for linear and nonlinear systems
4. Implementation of closed loop system using hardware simulation

PRE-REQISITE:

- Power electronics
- Solid state drives
- Power electronics circuits laboratory

LIST OF EXPERIMENTS

1. Speed control of Converter fed DC motor.
2. Speed control of Chopper fed DC motor.
3. V/f control of three-phase induction motor.
4. Micro controller based speed control of Stepper motor.
5. Speed control of BLDC motor.
6. DSP based speed control of SRM motor.
7. Voltage Regulation of three-phase Synchronous Generator.
8. Cyclo-converter fed Induction motor drives.
9. Single phase Multi Level Inverter based induction motor drive.
10. Study of power quality analyzer.

TOTAL: 30 PERIODS

WEB SOURCE(S):

1. https://nit.ac.in/pdf/labs/electrical/drives.pdf
2. https://www.researchgate.net/post/Electric_Drives_Laboratory_Equipment

COURSE OUTCOMES:

CO206.1 Ability to simulate different types of machines, converters in a system.

CO206.2 Analyze the performance of various electric drive systems.

CO206.3 Ability to perform both hardware and software simulation.

CO206.4 Ability to simulate the multi level inverter

CO206.5 To understand the basic concepts of Power Quality Anayzer

POs Vs COs MAPPING:

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO206.1	1	2		3				2		
CO206.2	1	2		3				2		
CO206.3	1	2		3				2		
CO206.4	1	2		3				2		
CO206.5	1	2		3				2		

1 ➐ Low 2 ➐ Medium 3 ➐ High

19PE2911	MINI PROJECT	L	T	P	C
		0	0	4	2

OBJECTIVCES:

1. To develop the ability to solve a specific problem right from its identification and literature review till the successful solution of the same.
2. To train the students in preparing project reports and to face reviews and viva voce examination.

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

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

TOTAL: 30 PERIODS

19PE2701	**POWER QUALITY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES:

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

PRE-REQISITE:

- POWER SYSTEM ANALYSIS

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

UNIT 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 real and reactive powers – Extraction of fundamental sequence component.

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 Dynamic Voltage Restorer – DC Capacitor supported DVR – DVR Structure – voltage Restoration – Series Active Filter – Unified Power Quality Conditioner.

TOTAL : 45 PERIODS

TEXT BOOKS:

1. ArindamGhosh “Power Quality Enhancement Using Custom Power Devices”, Kluwer Academic Publishers, 2002.
2. R.C. Duggan, Mark.F.McGranaghan,SuryaSantoas and H.WayneBeaty, Electrical Power System Quality”, McGraw-Hill, 2004.
3. G.T.Heydt, “Electric Power Quality”, Stars in a Circle Publications, 1994.
4. Bhim Singh, Ambrish Chandra, Kamal Al-Haddad , “Power Quality: Problems and Mitigation Techniques”, John Wiley & Sons,2015.

REFERENCES

1. Jos Arrillaga and Neville R. Watson ,“ Power system harmonics”,Wiley,2003.
2. Derek A. Paice , “Power Electronics Converter Harmonics :Multipulse Methods for Clean Power”,Wiley,1999.
3. Ewald Fuchs, Mohammad A. S. Masoum Power Quality in Power Systems and Electrical Machines, Elseveir academic press publications,2011.

WEB SOURCE(S):

1. https://nptel.ac.in/courses/108107157/
2. https://swayam.gov.in/nd1_noc20_ee10/preview

COURSE OUTCOMES:

CO204-1.1	Ability to formulate, design and simulate power supplies for generic load and machine loads.
CO204-1.2	Ability to conduct harmonic analysis and load tests on power supplies and drive systems.
CO204-1.3	Ability to understand and design load compensation methods useful for mitigating power quality problems.
CO204-1.4	Ability to understand the concept of power and power factor in single phase and three phase systems supplying nonlinear loads.
CO204-1.5	Ability to understand the active compensation techniques used for load voltage regulation.

POs Vs COs MAPPING:

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO204-1.1	2	1	1						1	
CO204-1.2	2	1	1						1	
CO204-1.3	2	1	1						1	
CO204-1.4	2	1	1						1	
CO204-1.5	2	1	1						1	

1. **1 ➐ Low 2 ➐ Medium 3 ➐ High**

19PE2702	ELECTROMAGNETIC FIELD COMPUTATION AND MODELLING	L	T	P	C
		3	0	0	3

OBJECTIVES:

1. To refresh the fundamentals of Electromagnetic Field Theory.
2. To provide foundation in formulation and computation of Electromagnetic Fields using analytical and numerical methods.
3. To impart in-depth knowledge on Finite Element Method in solving Electromagnetic field problems.
4. To introduce the concept of mathematical modeling and design of electrical apparatus.

PRE -REQUISITE:

- Field Theory
- Wave Equation
- Finite element Analysis

UNIT I INTRODUCTION 9

Review of basic field theory – Maxwell's equations – Constitutive relationships and Continuity equations – Laplace, Poisson and Helmholtz equation – principle of energy conversion – force/torque calculation.

UNIT II BASIC SOLUTION METHODS FOR FIELD EQUATIONS 9

Limitations of the conventional design procedure, need for the field analysis based design, problem definition, boundary conditions, solution by analytical methods-direct integration method – variable separable method – method of images, solution by numerical methods- Finite Difference Method.

UNIT III FORMULATION OF FINITE ELEMENT METHOD (FEM) 9

Variational Formulation – Energy minimization – Discretization – Shape functions – Stiffness matrix – 1D and 2D planar and axial symmetry problems.

UNIT IV COMPUTATION OF BASIC QUANTITIES USING FEM PACKAGES9

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 – Cylindrical magnetic actuators – Transformers – Rotating machines

TOTAL : 45 PERIODS

REFERENCES

1. Matthew. N.O. Sadiku, "Elements of Electromagnetics", Fourth Edition, Oxford University Press, First Indian Edition 2007
2. K.J.Binns, P.J.Lawrenson, C.W Trowbridge, "The analytical and numerical solution of Electric and magnetic fields", John Wiley & Sons, 1993.
3. Nicola Biyanchi , "Electrical Machine analysis using Finite Elements", Taylor and Francis Group, CRC Publishers, 2005.
4. Nathan Ida, Joao P.A.Bastos , "Electromagnetics and calculation of fields", SpringerVerlage, 1992.
5. S.J Salon, "Finite Element Analysis of Electrical Machines" Kluwer Academic Publishers, London, 1995, distributed by TBH Publishers & Distributors, Chennai, India
6. Silvester and Ferrari, "Finite Elements for Electrical Engineers" Cambridge University press, 1983

WEB RESOURCES:

1. https://nptel.ac.in/courses/108106073/
2. https://www.btechguru.com/campusg/listLectures.php?cid=05653f362e584452&bid=c6c45d988f670c72
3. https://www.ndt.net/search/docs.php3?showForm=off&id=3855

COURSE OUTCOMES:

CO204-2.1	Understand the concepts of electromagnetic Field.
CO204-2.2	Ability to formulate the FEM method and use of the package.
CO204-2.3	Apply the concepts in the design of rotating machines.
CO204-2.4	Ability to acquire in-depth knowledge on Finite Element Method in solving Electromagnetic field problems.
CO204-2.5	To understand concept of mathematical modeling of electrical apparatus.

POs Vs COs MAPPING:

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO204-2.1	3		3		2			2		
CO204-2.2	3		3		2			2		
CO204-2.3	3		3		2			2		
CO204-2.4	3		3		2			2		
CO204-2.5	3		3		2			2		

1. **1 ❼ Low 2 ❼ Medium 3 ❼ High**

19PE2703	CONTROL SYSTEM DESIGN FOR POWER ELECTRONICS	L	T	P	C
		3	0	0	3

OBJECTIVES:

1. To explore conceptual bridges between the fields of Control Systems and Power Electronics
2. To Study Control theories and techniques relevant to the design of feedback controllers in Power Electronics

COURSE OUTCOMES:

1. Ability to understand an overview on modern linear and nonlinear control strategies for power electronics devices
2. Ability to model modern power electronic converters for industrial applications
3. Ability to design appropriate controllers for modern power electronics devices.

PRE -REQUISITE:

- **Power Electronics**
- **Control System**

UNIT I MODELLING OF DC-TO-DC POWER CONVERTERS 9

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

UNIT II SLIDING MODE CONTROLLER DESIGN 9

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

UNIT III APPROXIMATE LINEARIZATION CONTROLLER DESIGN 9

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

UNIT IV NONLINEAR CONTROLLER DESIGN 9

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

UNIT V PREDICTIVE CONTROL OF POWER CONVERTERS 9

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

TOTAL : 45 PERIODS

WEB RESOURCES:

- https://www.springer.com/gp/book/9788132223276

REFERENCES

1. HeberttSira -Ramírez PhD, Ramón Silva -Ortigoza, "Control Design Techniques in Power Electronics Devices", Springer 2012
2. Mahesh Patil, PankajRodey, "Control Systems for Power Electronics: A Practical Guide", Springer India, 2015.
3. Blaabjerg José Rodríguez, "Advanced and Intelligent Control in Power Electronics and Drives" , Springer, 2014
4. Enrique Acha, VassiliosAgelidis, Olimpo Anaya, TJE Miller, "Power Electronic Control in Electrical Systems", Newnes, 2002
5. Marija D. Aranya Chakrabortty, Marija , "Control and Optimization Methods for Electric Smart Grids", Springer, 2012.

1. Ability to understand an overview on modern linear and nonlinear control strategies for power electronics devices
2. Ability to model modern power electronic converters for industrial applications
3. Ability to design appropriate controllers for modern power electronics devices.

COURSE OUTCOMES:

CO204-3.1	Ability to model DC-DC Converter
CO204-3.2	Ability to Design Sliding Mode controller Design
CO204-3.3	Ability to understand an overview on modern linear and nonlinear control strategies for power electronics devices.
CO204-3.4	Ability to understand an overview on modern linear and nonlinear control strategies for power electronics devices.
CO204-3.5	Ability to design appropriate controllers for modern power electronics devices

POs Vs COs MAPPING:

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO204-3.1	3		3		2			2		
CO204-3.2	3		3		2			2		
CO204-3.3	3		3		2			2		
CO204-3.4	3		3		2			2		
CO204-3.5	3		3		2			2		

1. **1 ➐ Low 2 ➐ Medium 3 ➐ High**

19PE2704 SOFT COMPUTING TECHNIQUES L T P C

3 0 0 3

OBJECTIVES:

1. To expose the concepts of feed forward neural networks.
2. To provide adequate knowledge about feedback neural networks.
3. To teach about the concept of fuzziness involved in various systems.
4. To expose the ideas about genetic algorithm
5. To provide adequate knowledge about of FLC and NN toolbox

PRE-REQUISITE:

- Engineering Physics
- Control Systems

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 propagation 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 modelling and control- Fuzzification inferencing and defuzzification - Fuzzy knowledge and rule bases-Fuzzy modelling 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

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 internationaledition, 2011.
4. David E.Goldberg, “Genetic Algorithms in Search, Optimization, and MachineLearning”, 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. Ethem Alpaydin, “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.

WEB SOURCES:

1. https://nptel.ac.in/courses/106/105/106105173/
2. https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/106105173/lec1.pdf

COURSE OUTCOMES:

CO204-4.1	Will be able to know the basic ANN architectures, algorithms and their limitations.
CO204-4.2	Will be able to know the different operations on the fuzzy sets.
CO204-4.3	Will be capable of developing ANN based models and control schemes for non-linear system.
CO204-4.4	Will get expertise in the use of different ANN structures and online training algorithm.
CO204-4.5	Will be knowledgeable to use Fuzzy logic for modeling and control of non-linear systems.

POs Vs COs MAPPING:

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO204-4.1	1	2			2			1		1
CO204-4.2	1	2			2			1		1
CO204-4.3	1	2			2			1		1
CO204-4.4	1	2			2			1		1
CO204-4.5	1	2			2			1		1

1. **1 ➐ Low 2 ➐ Medium 3 ➐ High**

19PE2705 FLEXIBLE AC TRANSMISSION SYSTEMS

L	T	P	C
3	0	0	3

OBJECTIVES:

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

PRE-REQISITE:

- High Voltage Direct Current Engineering
- High Voltage Engineering

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.

UNIT II STATIC VAR COMPENSATOR (SVC) 9

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

UNIT III THYRISTOR AND GTO THYRISTOR CONTROLLED SERIESCAPACITORS (TCSC and GCSC) 9

Concepts of Controlled Series Compensation – Operation of TCSC and GCSC- Analysis ofTCSC-GCSC – Modelling of TCSC and GCSC for load flow studies- modelling TCSC and GCSC for stability studied- Applications of TCSC and GCSC.

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 and IPFC)- Modelling of UPFC and IPFC for load flow and transient stability studies-Applications.

UNIT V CONTROLLERS AND THEIR COORDINATION 9

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

TOTAL : 45 PERIODS

REFERENCES:

1. A.T.John, "Flexible AC Transmission System", Institution of Electrical and Electronic Engineers (IEEE), 1999.
2. NarainG.Hingorani, Laszio. Gyugyl, "Understanding FACTS Concepts and Technology of Flexible AC Transmission System", Standard Publishers, Delhi 2001.
3. V. K.Sood, "HVDC and FACTS controllers- Applications of Static Converters in Power System", 2004, Kluwer Academic Publishers.
4. Mohan Mathur, R., Rajiv. K. Varma, "Thyristor – Based Facts Controllers for Electrical Transmission Systems", IEEE press and John Wiley & Sons, Inc.
5. K.R.Padiyar," FACTS Controllers in Power Transmission and Distribution", New Age International(P) Ltd., Publishers New Delhi, Reprint 2008.

WEB RESOURCES:

1. https://www.electrical4u.com/facts-on-facts-theory-and-applications/
2. https://www.gegridsolutions.com/facts.htm

COURSE OUTCOMES:

CO205-1.1	Ability to understand the operation of the ac transmission lines and various types of FACTS
CO205-1.2	Ability to understand the basic concepts of VAR compensators
CO205-1.3	Ability to know about the modeling and applications of thyistors and GTO
CO205-1.4	Ability to understand the basic concepts voltage source convertor based FACTS
CO205-1.5	Ability to analysis the various Controllers and their Coordination

POs Vs COs MAPPING:

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO205-1.1	2	2	1	2				2		
CO205-1.2	2	2	1	2				2		
CO205-1.3	2	2	1	2				2		
CO205-1.4	2	2	1	2				2		
CO205-1.5	2	2	1	2				2		

1 ❼ Low 2 ❼ Medium 3 ❼ High

19PE2706	MODERN RECTIFIERS AND RESONANT CONVERTERS	L	T	P	C
		3	0	0	3

OBJECTIVES:

1. To gain knowledge about the harmonics standards and operation of rectifiers in CCM &DCM.
2. To analyse and design power factor correction rectifiers for UPS applications.
3. To know the operation of resonant converters for SMPS applications.
4. To carry out dynamic analysis of DC- DC Converters.
5. To introduce the source current shaping methods for rectifiers.

PRE-REQISITE:

- Electromagnetic filed
- Power Converters
- Power System Analysis

UNIT I POWER SYSTEM HARMONICS & LINE COMMUTATED RECTIFIERS 9

Average power - RMS value of waveform–Effect of Power factor-. current and voltage harmonics – Effect of source and load impedance - AC line current harmonic standards IEC1000-IEEE 519-CCM and DCM operation of single phase full wave rectifier-Behaviour offull wave rectifier for large and small values of capacitance - CCM and DCM operation of three phase full wave rectifier- 12 pulse converters - Harmonic trap filters.

UNIT II PULSE WIDTH MODULATED RECTIFIERS 9

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

UNIT III RESONANT CONVERTERS 9

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

UNIT 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 an ideal Buck Converter, ideal Boost Converter, ideal Buck Boost Converter and an ideal Cuk Converter. Pulse Width modulation - Voltage Mode PWM Scheme - Current Mode PWM Scheme - design of PI controller.

UNIT V SOURCE CURRENT SHAPING OF RECTIFIERS 9

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

TOTAL 45 PERIODS

REFERENCES:

1. Robert W. Erickson and Dragon Maksimovic, “Fundamentals of Power Electronics”, Second Edition, Springer science and Business media, 2001.
2. William Shepherd and Li zhang, “Power Converters Circuits”, Marceld Ekkerin,C, 2005.
3. Simon Ang and Alejandro Oliva, “Power Switching Converters”, Taylor & Francis Group, 2010.

4. Andrzej M. Trzynadlowski, " Introduction To Modern Power Electronics", John Wiley &Sons, 2016.
5. Marian.K.Kazimierczuk and DariuszCzarkowski, “Resonant Power Converters”, John Wiley & Sons limited, 2011.
6. Keng C .Wu, “Switch Mode Power Converters – Design and Analysis” Elseveir academic press, 2006.
7. Abraham I.Pressman, Keith Billings and Taylor Morey, “ Switching Power Supply Design” McGraw-Hill ,2009.
8. V.Ramanarayanan, “Course Material on Switched Mode Power Conversion” IISC, Banglore, 2007.
9. Christophe P. Basso, Switch-Mode Power Supplies, McGraw-Hill ,2014.

WEB RESOURCES

- https://www.scribd.com/document/372768631/PX5004-MR-RC

COURSE OUTCOMES(S):

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

CO205-2.1 Ability to analysis of various types of rectifiers.

CO205-2.2 Simulate and design the operation of various PWM converters and its applications.

CO205-2.3 Identify the importance resonant converter and its importance

CO205-2.4 Design the various DC-DC converter techniques.

CO205-2.5 Understand the source current shaping for rectifiers.

POs Vs COs MAPPING:

CO No	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO205-2.1	3		2		3			2		
CO205-2.2	3		2		2			2		
CO205-2.3	3		2		3			2		
CO205-2.4	3		2		2			2		
CO205-2.5	3		2		3			2		

1. 1 → Low 2 → Medium 3 → High

19PE2707	**ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVCES:

1. To provide fundamental knowledge on electromagnetic interference and electromagnetic compatibility.
2. To study the important techniques to control EMI and EMC.
3. To expose the knowledge on testing techniques as per Indian and international standards in EMI measurement.

PRE-REQISITE:

- Electromagnetic Theory
- Transmission and Distribution
- FACTS
- Power System Analysis

UNIT I INTRODUCTION 9

Definitions of EMI/EMC -Sources of EMI- Inter systems and Intra system- Conducted and radiated interference- Characteristics - Designing for electromagnetic compatibility (EMC)- EMC regulation typical noise path- EMI predictions and modelling, Cross talk - Methods of eliminating interferences.

UNIT II GROUNDING AND CABLING 9

Cabling- types of cables, mechanism of EMI emission / coupling in cables –capacitive coupling inductive coupling- shielding to prevent magnetic radiation- shield transfer impedance, Grounding – safety grounds – signal grounds- single point and multipoint ground systems hybrid grounds- functional ground layout –grounding of cable shields- - guard shields- isolation, neutralizing transformers, shield grounding at high frequencies, digital grounding- Earth measurement Methods.

UNIT III BALANCING, FILTERING AND SHIELDING 9

Power supply decoupling- decoupling filters-amplifier filtering –high frequency filtering- EMI filters characteristics of LPF, HPF, BPF, BEF and power line filter design -Choice of capacitors, inductors, transformers and resistors, EMC design components -shielding – near and far fields shielding effectiveness- absorption and reflection loss- magnetic materials as a shield, shield discontinuities, slots and holes, seams and joints, conductive gaskets-windows and coatings - grounding of shields.

UNIT IV EMI IN ELEMENTS AND CIRCUITS 9

Electromagnetic emissions, noise from relays and switches, non-linearities in circuits, passive inter modulation, transients in power supply lines, EMI from power electronic equipment, EMI as combination of radiation and conduction.

UNIT V ELECTROSTATIC DISCHARGE, STANDARDS AND TESTING TECHNIQUES 9

Static Generation- human body model- static discharges- ESD versus EMC, ESD protection in equipments- standards – FCC requirements – EMI measurements – Open area test site measurements and precautions- Radiated and conducted interference measurements, Control requirements and testing methods.

TOTAL : 45 PERIODS

REFERENCES:

1. V.P. Kodali, "Engineering Electromagnetic Compatibility", S. Chand, 1996.
2. Henry W.Ott, " Noise reduction techniques in electronic systems", John Wiley & Sons, 1989.
3. Bernhard Keiser, "Principles of Electro-magnetic Compatibility", Artech House, Inc. (685 canton street, Norwood, MA 020062 USA) 1987.
4. Bridges, J.E Milleta J. and Ricketts.L.W., "EMP Radiation and Protective techniques", John Wiley and sons, USA 1976.
5. William Duff G., & Donald White R. J, "Series on Electromagnetic Interference and Compatibility", Vol.
6. Weston David A., "Electromagnetic Compatibility, Principles and Applications", 1991.

WEB RESOURCES:

1. https://www.sebokwiki.org/wiki/Electromagnetic_Interference/Electromagnetic_Compatibility
2. https://com-power.com/blog/emi-and-emc-differences
3. https://epd.wisc.edu/courses/introduction-to-electromagnetic-interference-and-compatibility-emi-emc/
4. https://www.ansys.com/products/electronics/electromagnetic-interference-compatibility
5. https://www.slideshare.net/sabeelirshad/electromagnetic-interference-electromagnetic-compatibility.

COURSE OUTCOMES:

CO205-3.1	Recognize the sources of Conducted and radiated EMI in Power Electronic Converters and consumer appliances and suggest remedial measures to mitigate the problems.
CO205-3.2	Assess the insertion loss and design EMI filters to reduce the loss.
CO205-3.3	Design EMI filters, common-mode chokes and RC-snubber circuits measures to keep the interference within tolerable limits.
CO205-3.4	Ability to understand the parameters of grounding and cables.
CO205-3.5	Ability to use different standards and testing techniques in electrostatic discharge.

POs Vs COs MAPPING:

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO205-3.1	3									2
CO205-3.2	3		2		2					2
CO205-3.3	3		3							2
CO205-3.4	3	3								2
CO205-3.5	3				3					2

1. **1 ❼ Low 2 ❼ Medium 3 ❼ High**

19PE2708	**POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES:

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

PRE-REQISITE:

- Power Electronics

UNIT I INTRODUCTION 9

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

UNIT II ELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION 9

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

UNIT III POWER ELECTRONICS FOR SOLAR 9

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

UNIT IV POWER ELECTRONICS FOR WIND 9

Three phase AC voltage controllers-AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, matrix converters- Stand alone operation of fixed and variable speed wind energy conversion systems- Grid connection Issues -Grid integrated PMSG and SCIG Based WECS.

UNIT V HYBRID RENEWABLE ENERGY SYSTEMS 9

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

TOTAL : 45 PERIODS

REFERENCES

1. S.N.Bhadra, D. Kastha, & S. Banerjee "Wind Electrical Systems", Oxford UniversityPress, 2009.
2. Rashid .M. H "power electronics Hand book", Academic press, 2001.
3. Rai. G.D, "Non conventional energy sources", Khanna publishes, 1993.
4. Rai. G.D," Solar energy utilization", Khanna publishes, 1993.
5. Gray, L. Johnson, "Wind energy system", prentice hall linc, 1995.
6. B.H.Khan, " Non-conventional Energy sources", Tata McGraw-hill PublishingCompany.
7. P.S.Bimbhra,"Power Electronics",Khanna Publishers, 3rd Edition,2003.
8. Fang Lin Luo Hong Ye, " Renewable Energy systems", Taylor & Francis Group,2013.
9. R.Seyezhai and R.Ramaprabha, "Power Electronics for Renewable Energy Systems", Scitech Publications, 2015.

WEB SOURCE(S):

https://nptel.ac.in/courses/108108034/

COURSE OUTCOMES:

CO205-4.1 Analyze the impacts of renewable energy generation on environment.

CO205-4.2 Understand the importance and qualitative analysis of solar and wind energy sources.

CO205-4.3 Apply the principle of operation of electrical machines for wind energy conversion and their performance characteristics.

CO205-4.4 Design suitable power converters for solar PV and wind energy systems.

CO205-4.5 Ability to design different power converters namely AC to DC, DC to DC and AC to AC converters for renewable energy systems.

POs Vs COs MAPPING:

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO205-4.1	1					1	2		1	
CO205-4.2	1					1	2		1	
CO205-4.3	1					1	2		1	
CO205-4.4	1					1	2		1	
CO205-4.5	1					1	2		1	

1 ❼ Low 2 ❼ Medium 3 ❼ High

19PE2709 DISTRIBUTED GENERATION AND MICROGRID

L	T	P	C
3	0	0	3

OBJECTIVES:

1. To illustrate the concept of distributed generation
2. To analyse the impact of grid integration.
3. To study concept of Micro grid and its configuration

PRE-REQISITE:

- Power Electronics
- Power Generation Systems
- Solid state drives
- Power system operation and control

UNIT I INTRODUCTION 9

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

UNIT II DISTRIBUTED GENERATIONS (DG) 9

Concept of distributed generations, topologies, selection of sources, regulatory standards/ framework, Standards for interconnecting Distributed resources to electric power systems: IEEE 1547. DG installation classes, security issues in DG implementations. Energy storage elements: Batteries, ultra-capacitors, flywheels. Captive power plants

UNIT III IMPACT OF GRID INTEGRATION 9

Requirements for grid interconnection, limits on operational parameters,: voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues. Impact of grid integration with NCE sources on existing power system: reliability, stability and power quality issues.

UNIT IV BASICS OF A MICROGRID 9

Concept and definition of micro grid, micro grid drivers and benefits, review of sources of micro grids, typical structure and configuration of a micro grid, AC and DC micro grids, Power Electronics interfaces in DC and AC micro grids.

UNIT V CONTROL AND OPERATION OF MICROGRID 9

Modes of operation and control of micro grid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques, micro grid communication infrastructure, Power quality issues in micro grids, regulatory standards, Micro grid economics, Introduction to smart micro grids.

TOTAL : 45 PERIODS

REFERENCES:

1. AmirnaserYezdani, and Reza Iravani, "Voltage Source Converters in Power Systems: Modeling, Control and Applications", IEEE John Wiley Publications, 2010.
2. DorinNeacsu, "Power Switching Converters: Medium and High Power", CRC Press,Taylor & Francis, 2006.
3. Chetan Singh Solanki, "Solar Photo Voltaics", PHI learning Pvt. Ltd., New Delhi,2009.
4. J.F. Manwell, J.G. McGowan "Wind Energy Explained, theory design and applications", Wiley publication 2010.
5. D. D. Hall and R. P. Grover, "Biomass Regenerable Energy", John Wiley, New York, 1987.
6. John Twidell and Tony Weir, "Renewable Energy Resources" Tyalor and Francis Publications, Second edition 2006.

WEB SOURCE(S):

- https://nptel.ac.in/courses/108107143/
- https://nptel.ac.in/courses/108/108/108108034/
- https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/108107143/lec2.pdf

COURSE OUTCOME(S):

CO205-5.1	Learners will attain knowledge on the various schemes of conventional and nonconventional power generation.
CO205-5.2	Learners will have knowledge on the topologies and energy sources of distributed generation.
CO205-5.3	Learners will learn about the requirements for grid interconnection and its impact with NCE sources
CO205-5.4	Learners will understand the fundamental concept of Micro grid.
CO205-5.5	Learners will understand the control and operation of Micro grid.

POs Vs COs MAPPING:

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO205-5.1	2		2							
CO205-5.2	2		2							
CO205-5.3	2		2		2					
CO205-5.4	2		2							
CO205-5.5	2		2							

1 ➐ Low 2 ➐ Medium 3 ➐ High

19PE2710	ANALOG AND DIGITAL CONTROLLERS	L	T	P	C
		3	0	0	3

OBJECTIVES:

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

PRE REQUISTE

- Basic Electronics
- Control system
- Analog and Digital systems

UNIT I CONTROL SYSTEM - OVERVIEW 9

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

UNIT II ANALOG CONTROLLERS 9

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

UNIT III DIGITAL CONTROLLERS 9

Micro Controllers and Digital Signal Controllers for Converter Control Application, Interface Modules for Converter Control – A/D, Capture, Compare and PWM, Analog Comparators for instantaneous over current detection, interrupts, Discrete PI and PID equations, Algorithm for PI and PID implementation, Example Code for PWM generation.

UNIT IV SIGNAL CONDITIONING, DRIVER, ISOLATION AND PROTECTION 9

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

UNIT V CONTROLLER IMPLEMENTATION 9

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

TOTAL : 45 PERIODS

REFERENCES:

1. I.J. Nagrath and M. Gopal, "Control Systems Engineering", New Age International Publishers.
2. TI Application notes, Reference Manuals and Data Sheets.
3. Agilent Data Sheets.
4. Microchip Application notes, Reference Manuals and Data Sheets.

WEB RESOURCES:

1. https://nptel.ac.in/content/storage2/courses/108103008/PDF/module1/m1_lec1.pdf
2. https://nptel.ac.in/courses/108103008/

COURSE OUTCOME(S):

CO205-6.1	Ability to understand the overview of the control system and converter control methodologies
CO205-6.2	Ability to study the anlog controllers
CO205-6.3	Ability to understand the concept on Embedded Processers for Digital Control.
CO205-6.4	Ability to study driving techniques
CO205-6.5	Ability to know the Case Study of implementing an analog and a digital controller on a converter.

POs Vs COs MAPPING:

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO205-6.1	2		2					2		
CO205-6.2	2		2					2		2
CO205-6.3	2		2		2			2		2
CO205-6.4	2		2					2		
CO205-6.5	2		2					2		

1. **1 ➐ Low 2 ➐ Medium 3 ➐ High**

19PE3701	HIGH VOLTAGE DIRECT CURRENTTRANSMISSION	L	T	P	C
		3	0	0	3

OBJECTIVES:

1. To impart knowledge on operation, modelling and control of HVDC link.
2. To perform steady state analysis of AC/DC system.
3. To expose various HVDC simulators.

PRE-REQISITE:

- Power Electronics
- Power Generation Systems
- Power systems Analysis
- Power system operation and control

UNIT I DC POWER TRANSMISSION TECHNOLOGY 9

Introduction - Comparison of AC and DC transmission – Application of DC transmission – Description of DC transmission system - Planning for HVDC transmission – Modern trends in DC transmission – DC breakers – Cables, VSC based HVDC.

UNIT II THYRISTOR BASED HVDC CONVERTERS AND HVDC SYSTEM CONTROL 9

Pulse number, choice of converter configuration – Simplified analysis of Graetz circuit - Converter bridge characteristics – characteristics of a twelve pulse converter- detailed analysis of converters. General principles of DC link control – Converter control characteristics – System control hierarchy - Firing angle control – Current and extinction angle control – Generation of harmonics and filtering - power control – Higher level controllers-Valve tests.

UNIT III MULTITERMINAL DC SYSTEMS 9

Introduction – Potential applications of MTDC systems - Types of MTDC systems – Control and protection of MTDC systems - Study of MTDC systems.

UNIT IV POWER FLOW ANALYSIS IN AC/DC SYSTEMS **9**

Per unit system for DC Quantities - Modelling of DC links - Solution of DC load flow - Solution of AC-DC power flow – Unified, Sequential and Substitution of power injection method

UNIT V SIMULATION OF HVDC SYSTEMS **9**

Introduction – DC LINK Modelling , Converter Modelling and State Space Analysis , Philosophy and tools – HVDC system simulation, Online and OFF line simulators — Dynamic interactions between DC and AC systems.

TOTAL : 45 PERIODS

REFERENCES

1. P. Kundur, "Power System Stability and Control", McGraw-Hill, 1993
2. K.R.Padiyar, , "HVDC Power Transmission Systems", New Age International (P) Ltd., New Delhi, 2002
3. J.Arrillaga, , "High Voltage Direct Current Transmission", Peter Pregrinus, London, 1983
4. rich Uhlmann, " Power Transmission by Direct Current", BS Publications, 2004.
5. V.K.Sood,HVDC and FACTS controllers – Applications of Static Converters in Power System, APRIL 2004 , Kluwer Academic Publishers.

WEB SOURCE(S):

1. https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/108104013/lec1.pdf
2. https://www.cet.edu.in/noticefiles/229_HVDC_NOTE.pdf
3. https://nptel.ac.in/content/syllabus_pdf/108104013.pdf

COURSE OUTCOME(S):

The students will able to

CO301-1.1	Understand knowledge on operation, modeling and control of HVDC link
CO301-1.2	Understand knowledge on thyristor based HVDC converters
CO301-1.3	Understand knowledge on multi terminal DC systems
CO301-1.4	Understand knowledge on power flow analysis in AC/DC systems
CO301-1.5	Expose various HVDC simulators.

POs Vs COs MAPPING:

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO301-1.1	2									3
CO301-1.2	2									3
CO301-1.3	2									3
CO301-1.4	2									3
CO301-1.5	2		2		2			2		3

1. **1 Low 2 Medium 3 High**

19PE3702 NON LINEAR CONTROL

L	T	P	C
3	0	0	3

OBJECTIVES:

1. To impart knowledge on phase plane analysis of non-linear systems.
2. To impart knowledge on Describing function based approach to non-linear systems.
3. To educate on stability analysis of systems using Lyapunov's theory.
4. To educate on stability analysis of systems using Lyapunov's theory.
5. To introduce the concept of sliding mode control.

PRE-REQISITE:

- Control system

UNIT I PHASE PLANE ANALYSIS 9

Concepts of phase plane analysis- Phase portraits- singular points- Symmetry in phase plane portraits-Constructing Phase Portraits- Phase plane Analysis of Linear and Nonlinear Systems- Existence of Limit Cycles. simulation of phase portraits in MATLAB.

UNIT II DESCRIBING FUNCTION 9

Describing Function Fundamentals-Definitions-Assumptions-Computing Describing Functions- Common Nonlinearities and its Describing Functions-Nyquist Criterion and its Extension- Existence of Limit Cycles-Stability of limit Cycles. simulation of limit cycles in MATLAB.

UNIT III LYAPUNOV THEORY 9

Nonlinear Systems and Equilibrium Points-Concepts of Stability-Linearization and Local Stability- Lyapunov's Direct Method-Positive definite Functions and Lyapunov Functions-Equilibrium Point Theorems-Invariant Set Theorems-LTI System Analysis based on Lyapunov's Direct Method- Krasovski's Method-Variable Gradient Method-Physically – Control Design based on Lyapunov's Direct Method.

UNIT IV FEEDBACK LINEARIZATION 9

Feedback Linearization and the Canonical Form-Mathematical Tools-Input-State Linearization of SISO Systems- input-Output Linearization of SISO Systems-Generating a Linear Input-Output Relation -Normal Forms-The Zero-Dynamics-Stabilization and Tracking- Inverse Dynamics and Non- Minimum-Phase Systems-Feedback Linearization of MIMO Systems Zero-Dynamics and Control Design. Simulation of tracking problems in MATLAB.

UNIT V SLIDING MODE CONTROL 9

Sliding Surfaces - Continuous approximations of Switching Control laws - The Modelling/ Performance Trade-Offs- MIMO Systems. simulation of sliding mode controller in MATLAB.

TOTAL : 45 PERIODS

REFERENCES

1. J A E Slotine and W Li, Applied Nonlinear control, PHI, 1991.
2. K. P. Mohandas, Modern Control Engineering, Sanguine, India, 2006
3. Hasan Khalil, "Nonlinear systems and control", Prentice Hall.
4. S H Zak, "Systems and control", Oxford University Press, 2003.
5. Torkel Glad and Lennart Ljung, "Control Theory – Multivariable and NonlinearMethods",Taylor& Francis, 2002.

COURSE OUTCOMES:

CO301-2.1	Understand the concepts of non-linear control system.
CO301-2.2	Analyze the stability of the system.
CO301-2.3	Illustrate the sliding mode control and implementation in MATLAB
CO301-2.4	Ability to educate on stability analysis of systems using Lyapunov's theory.
CO301-2.5	Ability to impart knowledge on Describing function based approach to

non-linear systems.

POs Vs COs MAPPING:

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO301-2.1	1	1	2						2	
CO301-2.2	1	1	2						2	
CO301-2.3	1	1	2						2	
CO301-2.4	1	1	2						2	
CO301-2.5	1	1	2						2	

1 ➐ Low 2 ➐ Medium 3 ➐ High

19PE3703 WIND ENERGY CONVERSION SYSTEMS L T P C

3 0 0 3

OBJECTIVES:

1. To learn the design and control principles of Wind turbine.
2. To understand the concepts of fixed speed and variable speed, wind energy conversion systems.
3. To analyze the grid integration issues.

PRE-REQUISITE:

- Power Electronics for Renewable Energy Systems

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 WIND TURBINES 9

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

UNIT III FIXED SPEED SYSTEMS 9

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

UNIT IV VARIABLE SPEED SYSTEMS 9

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

UNIT V GRID CONNECTED SYSTEMS 9

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

TOTAL : 45 PERIODS

REFERENCES

1. L.L.Freris "Wind Energy conversion Systems", Prentice Hall, 1990
2. S.N.Bhadra, D.Kastha,S.Banerjee,"Wind Electrical Systems",Oxford UniversityPress,2010.
3. Ion Boldea, "Variable speed generators", Taylor & Francis group, 2006.
4. E.W.Golding "The generation of Electricity by wind power", Redwood burnLtd.,Trowbridge,1976.
5. N. Jenkins," Wind Energy Technology" John Wiley & Sons,1997
6. S.Heir "Grid Integration of WECS", Wiley 1998.

WEB SOURCES:

1. https://nptel.ac.in/content/storage2/courses/108108078/pdf/chap6/teach_slides06.pdf
2. https://nptel.ac.in/courses/108/105/108105058/

COURSE OUTCOMES:

CO301-3.1	Acquire knowledge on the basic concepts of Wind energy conversion system.
CO301-3.2	Understand the mathematical modelling and control of the Wind turbine
CO301-3.3	Develop more understanding on the design of Fixed speed system
CO301-3.4	Study about the need of Variable speed system and its modelling.
CO301-3.5	Able to learn about Grid integration issues and current practices of wind interconnections with power system.

POs Vs COs MAPPING:

Co No.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO301-3.1	2	2	1		2			2		
CO301-3.2	2	2	1		2			2		
CO301-3.3	2	2	1		2			2		
CO301-3.4	2	2	1		2			2		
CO301-3.5	2	2	1		2			2		

1. 1 ➐ Low 2 ➐ Medium 3 ➐ High

19PE3704 OPTIMIZATION TECHNIQUES

L	T	P	C
3	0	0	3

OBJECTIVCES:

1. To understand the concept of various Optimization Techniques
2. To acquire an in-depth knowledge on application of Optimization Techniques to Power Electronics
3. To get detailed understanding of Optimization Techniques Applied to extract maximum power from photo voltaic systems and Wind Electric conversion System.

PRE-REQUISITE:

- Engineering Mathematics

UNIT I INTRODUCTION 9

Introduction to fitness evaluation, Definition-classification of optimization problems, unconstrained and constrained optimization, optimality conditions, classical optimization techniques (Linear and non linear programming, Quadratic programming, Mixed integer programming)-. Encoding and decoding functions, Introduction to constraint-handling techniques.

UNIT II EVOLUTIONARY COMPUTATION TECHNIQUES 9

Fundamentals of evolutionary algorithms-principle of simple Genetic Algorithm-Evolutionary Strategy and Evolutionary Programming- Direction based Search-Genetic operators-selection, crossover and mutation- issues in GA implementation.

UNIT III ADVANCED OPTIMIZATION METHODS 9

Fundamental principle, velocity updating, advanced operators, hybrid approaches implementation issues (Hybrid of GA and PSO, Hybrid of EP and PSO); Simplifying Particle Swarm Optimization, Optimizer Simplification & Meta-Optimization. Fundamental principle, Classification of Differential evolution techniques, Bacterial foraging, Bees colony algorithm, Concept of MPPT.

UNIT IV MULTI OBJECTIVE OPTIMIZATION 9

Concept of pareto optimality-Conventional approaches for MOOP-Multi objective GA-Fitness assignment-Sharing function-NSGA-II, -Multi objective PSO (Dynamic neighbourhood PSO, Vector evaluated PSO)

UNIT V OPTIMISATION TECHNIQUE APPLIED TO POWER ELECTRONICS APPLICATIONS 9

Passive filter design using genetic algorithm, harmonics elimination in inverters, Tuning of controllers, PV systems-Wind Electric conversion System - GA, PSO, DE, Optimized fuzzy logic control for the Maximum Power Point Tracking (MPPT).

REFERENCES:

1. SingiresuS. Rao, ”Engineering Optimization – Theory and Practice” by John Wiley & Sons, Inc., New Jersey, 2009.
2. Kothari D.P. and Dillon J.S., “Power system optimization”, PHI, 2004.

3. Thomas Back, David B Fogel and Zbigniew Michalewicz, “Evolutionary Computation 2 Advanced Algorithms and Operators” Institute of Physics Publishing, UK, 2000.
4. Kalyanmoy Deb, “Muti-objective Optimization using Evolutionary Algorithms”, John Wiley & Sons 2001.
5. Kennedy J, Swarm Intelligence, Morgan Kaufmann Publishers, Eberhart R 2001.

WEB RESOURCES:

1. https://www.youtube.com/watch?v=7KxlpQIbKUw
2. https://www.youtube.com/watch?v=bc3ysHc5RH0

COURSE OUTCOMES:

CO301-4.1	Understand the concepts of various Optimization Techniques.
CO301-4.2	Understand the concepts of Advanced Optimization Techniques.
CO301-4.3	Acquire an in-depth knowledge on application of Optimization Techniques to Power Electronics .
CO301-4.4	Understand Optimization Techniques applied to extract maximum power from photo voltaic systems.
CO301-4.5	Understand Optimization Techniques applied to extract maximum power Wind Electric conversion System.

POs Vs COs MAPPING:

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO301-4.1	3		3					2		2
CO301-4.2	3		3					2		2
CO301-4.3	3		3					2		2
CO301-4.4	3		3					2		2
CO301-4.5	3		3					2		2

1. **1 ❼ Low 2 ❼ Medium 3 ❼ High**

		L	T	P	C
19PE3705	**ELECTRIC AND HYBRID VEHICLES**	**3**	**0**	**0**	**3**

COURSE OBJECTIVE:

1. To present a comprehensive overview of Electric and Hybrid Electric Vehicles

PRE REQUISTE:

- Electrical Machines-I
- Electrical machines-II
- Electric Circuit Analysis

UNIT I ELECTRIC VEHICLES **9**

Introduction, Components, vehicle mechanics – Roadway fundamentals, vehicle kinetics, Dynamics of vehicle motion - Propulsion System Design.

UNIT II BATTERY **9**

Basics – Types, Parameters – Capacity, Discharge rate, State of charge, state of Discharge, Depth of Discharge, Technical characteristics, Battery pack Design, Properties of Batteries.

UNIT III DC & AC ELECTRICAL MACHINES **9**

Motor and Engine rating, Requirements, DC machines, Three phase A/c machines, Induction machines, permanent magnet machines, switched reluctance machines.

UNIT IV ELECTRIC VEHICLE DRIVE TRAIN **9**

Transmission configuration, Components – gears, differential, clutch, brakes regenerative braking, motor sizing.

UNIT V HYBRID ELECTRIC VEHICLES **9**

Types – series, parallel and series, parallel configuration – Design – Drive train, sizing of components.

TOTAL: 45 PERIODS

TEXT BOOKS

1. Iqbal Hussain, “Electric & Hybrid Vehicles – Design Fundamentals”, Second Edition, CRC Press, 2011.
2. James Larminie, “Electric Vehicle Technology Explained”, John Wiley & Sons, 2003.

REFERENCES

1. Mehrdad Ehsani, Yimin Gao, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals", CRC Press, 2010.
2. Sandeep Dhameja, "Electric Vehicle Battery Systems", Newnes, 2000

WEB RESOURCE(S):

- https://nptel.ac.in/courses/108102121/

COURSE OUTCOMES:

CO301-5.1	Ability to choose a suitable drive scheme for developing an electric hybrid vehicle depending on resources
CO301-5.2	Ability to design and develop basic schemes of electric vehicles and hybrid electric vehicles
CO301-5.3	Complete knowledge about the electrical machines that can be used for the e-vehicles
CO301-5.4	Ability to design the drive for the e-vehicles.
CO301-5.5	Choose proper energy storage systems for vehicle applications

POs Vs COs MAPPING:

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO301-5.1	1		1					1		1
CO301-5.2	1	2	1		1			2		2
CO301-5.3	2		2		2			3		2
CO301-5.4	2		2					3		3
CO301-5.5	3		3					3		3

1. 1 ⇾ Low 2 ⇾ Medium 3 ⇾ High

19PE3706	NON LINEAR DYNAMICS FOR POWER ELECTRONICS CIRCUITS	L	T	P	C
		3	0	0	3

OBJECTIVES:

1. To understand the non-linear behaviour of power electronic converters.
2. To understand the techniques for investigation on non-linear behaviour of power electronic converters
3. To analyse the non-linear phenomena in DC to DC converters.
4. To analyse the non-linear phenomena in AC and DC Drives.

5. To introduce the control techniques for control of non linear behavior in power electronic systems.

PRE-REQISITE:

- Power Electronics
- Solid State Drives

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

REFERENCES:

1. George C. Vargheese, July 2001 Wiley – IEEE Press S Banerjee, Nonlinear Phenomena in Power Electronics, IEEE Press 3.
2. Steven H Strogatz, Nonlinear Dynamics and Chaos, Westview Press
3. C.K.TSE Complex Behaviour of Switching Power Converters, CRC Press, 2003

WEB RESOURSES:

1. https://www.tandfonline.com/doi/abs/10.1080/1448837X.2004.11464093
2. http://www1.iitkgp.ac.in/academics/book_details.php?book_id=7

COURSE OUTCOMES:

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

CO301-6.1 Ability to determine the non-linear phenomena

CO301-6.2 Understand the basic concepts of investigation of nonlinear phenomena

CO301-6.3 To understand needs of DC- DC converters

CO301-6.4 Ability to understand nonlinear phenomena in drives

CO301-6.5 To analyse the basic concept of control of CHAOS

POs Vs COs MAPPING:

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO301-6.1	3	2	1					2		
CO301-6.2	3	2	1					2		
CO301-6.3	3	2	1					2		
CO301-6.4	3	2	1					2		
CO301-6.5	3	2	1					2		

1. 1 ➐ Low 2 ➐ Medium 3 ➐ High

19PE3707 SMART GRID

L	T	P	C
3	0	0	3

OBJECTIVCES:

1. To Study about Smart Grid technologies, different smart meters and advanced metering infrastructure.
2. To familiarize the power quality management issues in Smart Grid.
3. To familiarize the high performance computing for Smart Grid applications

PRE -REQUISITE:

- Transmission & Distribution
- Power System Analysis

UNIT I INTRODUCTION TO SMART GRID 9

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

UNIT II SMART GRID TECHNOLOGIES 9

Technology Drivers, Smart 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).

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), Intelligent Electronic Devices (IED) & their application for monitoring & protection.

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 GRIDAPPLICATIONS 9

Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN),Broadband over Power line (BPL), IP based Protocols, Basics of Web Service and cloud Computing to make Smart Grids smarter, Cyber Security for Smart Grid.

TOTAL : 45 PERIODS

REFERENCES

1. Stuart Borlase "Smart Grid: Infrastructure, Technology and Solutions", CRC Press 2012.
2. Janaka Ekanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", Wiley 2012.
3. Vehbi C. Güngör, DilanSahin, TaskinKocak, Salih Ergüt, ConcettinaBuccella, Carlo Cecati, and Gerhard P. Hancke, "Smart Grid Technologies: Communication Technologies and Standards" IEEE Transactions On Industrial Informatics, Vol. 7, No. 4, November 2011.
4. Xi Fang, SatyajayantMisra, Guoliang Xue, and Dejun Yang "Smart Grid – The NewandImproved Power Grid: A Survey" , IEEE Transaction on Smart Grids, vol. 14, 2012.

WEB RESOURCES:

1. https://nptel.ac.in/courses/108/107/108107113/
2. http://www.digimat.in/nptel/courses/video/108107113/108107113.html
3. http://www.digimat.in/nptel/courses/video/108107113/108107113.html

COURSE OUTCOMES:

CO301-7.1	Learners will develop more understanding on the concepts of Smart Grid and its present developments.
CO301-7.2	Learners will study about different Smart Grid technologies.
CO301-7.3	Learners will acquire knowledge about different smart meters and advanced metering infrastructure.
CO301-7.4	Learners will have knowledge on power quality management in Smart Grids.
CO301-7.5	Learners will develop more understanding on LAN, WAN and Cloud Computing for Smart Grid applications.

POs Vs COs MAPPING:

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO301-7.1	3		3			2			2	2
CO301-7.2	3		3			2			2	2
CO301-7.3	3		3			2			2	2
CO301-7.4	3		3			2			2	2
CO301-7.5	3		3			2			2	2

1. **1 → Low 2 → Medium 3 → High**

19PE3708	MEMS TECHNOLOGY	L	T	P	C
		3	0	0	3

OBJECTIVCES:

1. To teach the students properties of materials, microstructure and fabrication methods.
2. To teach the design and modeling of Electrostatic sensors and actuators.
3. To teach the characterizing thermal sensors and actuators through design and modelling.
4. To teach the fundamentals of piezoelectric sensors and actuators through exposure to different MEMS and NEMS devices.
5. To involve Discussions/ Practice/Exercise onto revising & familiarizing the concepts acquired over the 5 Units of the subject for improved employability skills.

PRE-REQISITE:

- Engineering Physics
- Measurements and Instrumentation

UNIT I MICRO-FABRICATION, MATERIALS AND ELECTRO-MECHANICAL CONCEPTS 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 piezoelectric actuator model-properties of piezoelectric materials- Applications.

UNIT V CASE STUDIES 9

Piezo resistive sensors, Magnetic actuation, Micro fluidics applications, Medical applications, Optical MEMS.-NEMS Devices Note: Class room discussions and tutorials can include the following guidelines for improved teaching /learning process: Discussions/Exercise/Practice on Workbench: on the basics /device model design aspects of thermal/peizo/resistive sensors etc.

TOTAL : 45 PERIODS

REFERENCES:

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

WEB SOURCE(S):

1. https://www.mems-exchange.org/MEMS/what-is.html
2. https://nptel.ac.in/courses/108108113/

COURSE OUTCOMES(S):

CO301-8.1	Understand basics of micro fabrication develop models and simulate electrostatic and electromagnetic sensors and actuators.
CO301-8.2	Understand material properties important for MEMS system performance, analyze dynamics of resonant micromechanical structures
CO301-8.3	The learning process delivers insight onto design of micro sensors, embedded sensors &actuators in power aware systems like grid.
CO301-8.4	Understand the design process and validation for MEMS devices and systems, and learn the state of the art in Piezoelectric systems.
CO301-8.5	Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded systems design.

POs Vs COs MAPPING:

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO301-8.1			3	1	2			2		2
CO301-8.2			3	1	2			2		2
CO301-8.3			3	1	2			2		2
CO301-8.4			3	1				2		2
CO301-8.5			3		2			2		2

1. **1 ➐ Low 2 ➐ Medium 3 ➐ High**

19PE3709 ROBOTICS AND CONTROL

L	T	P	C
3	0	0	3

OBJECTIVCES:

1. To introduce robot terminologies and robotic sensors To educate direct and inverse kinematic relations
2. To educate on formulation of manipulator Jacobian's and introduce path planning techniques
3. To educate on robot dynamics
4. To introduce robot control techniques

PRE REQUISTE

- Basic Mathematics
- Engineering Mechanics
- Control systems

UNIT I INTRODUCTION AND TERMINOLOGIES 9

Definition-Classification-History- Robots components-Degrees of freedom-Robot joints-coordinates-Reference frames-workspace-Robot languages-actuators-sensors-Position, velocity and acceleration sensors-Torque sensors-tactile and touch sensors-proximity and range sensors- vision system-social issues.

UNIT II KINEMATICS 9

Mechanism-matrix representation-homogenous transformation-DH representation-Inverse kinematics solution and programming-degeneracy and dexterity

UNIT III DIFFERENTIAL MOTION AND PATH PLANNING 9

Jacobian-differential motion of frames-Interpretation-calculation of Jacobian-Inverse Jacobian- Robot Path planning

UNIT IV DYNAMIC MODELLING 9

Lagrangian mechanics- Two-DOF manipulator- Lagrange-Euler formulation – Newton- Euler formulation – Inverse dynamics

UNIT V ROBOT CONTROL SYSTEM 9

- Linear control schemes- joint actuators- decentralized PID control- computed torque control –force control- hybrid position force control- Impedance/ Torque control

TOTAL : 45 PERIODS

REFERENCES

1. R.K. Mittal and I J Nagrath, “ Robotics and Control”, Tata MacGraw Hill, Fourth edition.
2. Saeed B. Niku ,"Introduction to Robotics ", Pearson Education, 2002.
3. Fu, Gonzalez and Lee Mcgrahill ,"Robotics ", international edition.
4. R.D. Klafter, TA Chmielewski and Michael Negin, "Robotic Engineering, An Integrated approach",Prentice Hall of India, 2003.

WEB RESOURCES:

1. https://nptel.ac.in/courses/112107289/
2. https://nptel.ac.in/courses/112101099/
3. https://swayam.gov.in/nd1_noc20_me03/preview

CO301-9.1	Ability to understand the components and basic terminology of Robotics
CO301-9.2	Ability to model the motion of Robots and analyze the workspace and trajectory panning of robots
CO301-9.3	Ability to develop application based Robots
CO301-9.4	Ability to create dynamic modelling
CO301-9.5	Ability to formulate models for the control of mobile robots in various industrial applications

POs Vs COs MAPPING:

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO301-9.1	2		2		3					
CO301-9.2	2		3		2					
CO301-9.3	2		3		3					
CO301-9.4	2	2	3							
CO301-9.5	2	2								

1. **1 ❼ Low 2 ❼ Medium 3 ❼ High**