SRI SAIRAM ENGINEERING COLLEGE
IQAC
Ensuring Quality
ALUMNI | STUDENT | MANAGEMENT | FACULTY | INDUSTRY

Sri SAI RAM ENGINEERING COLLEGE

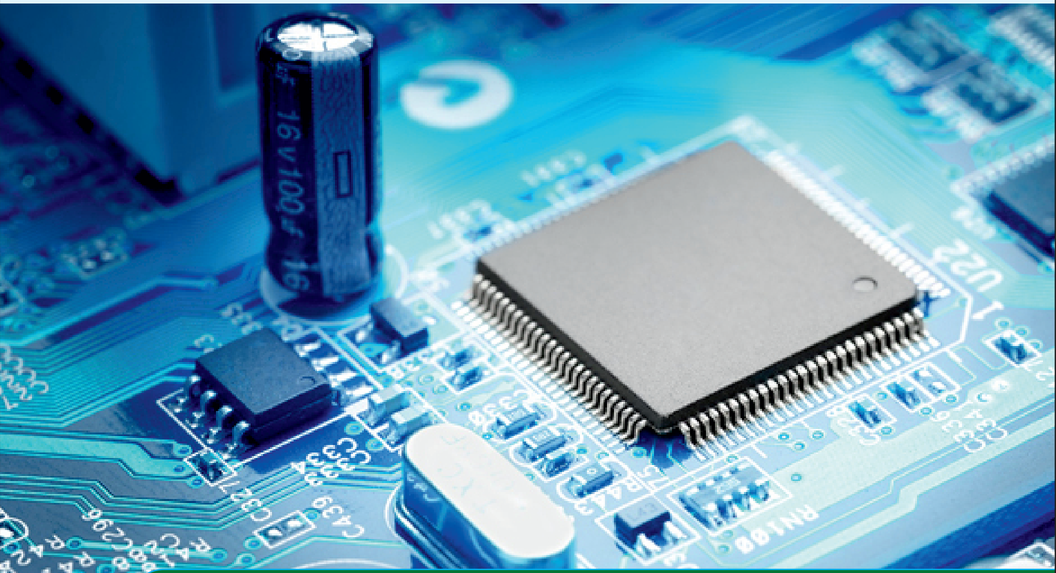
An Autonomous Institution

West Tambaram, Chennai - 44

www.sairam.edu.in

Approved by AICTE, New Delhi
Affiliated to Anna University

NBA NATIONAL BOARD of ACCREDITATION | NAAC NATIONAL ASSESSMENT AND ACCREDITATION COUNCIL A+ ACCREDITED | nirf NATIONAL INSTITUTIONAL RANKING FRAMEWORK | ISO 21001 EOMS | DIAMOND QS I-GAUGE | ISO 9001 : 2015 BUREAU VERITAS Certification



DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

M.E. POWER ELECTRONICS & DRIVES

AUTONOMOUS

REGULATIONS 2024

Academic Year 2024-25 onwards

PG CURRICULUM AND SYLLABUS I - IV SEMESTERS

SRI SAIRAM ENGINEERING COLLEGE

VISION

To emerge as a "Centre of excellence " offering Technical Education and Research opportunities of very high standards to students, develop the total personality of the individual and instil high levels of discipline and strive to set global standards, making our students technologically superior and ethically stronger, who in turn shall contribute to the advancement of society and humankind.

MISSION

We dedicate and commit ourselves to achieve, sustain and foster unmatched excellence in Technical Education. To this end, we will pursue continuous development of infra-structure and enhance state-of-the-art equipment to provide our students a technologically up-to date and intellectually inspiring environment of learning, research, creativity, innovation and professional activity and inculcate in them ethical and moral values.

QUALITY POLICY

We at Sri Sai Ram Engineering College are committed to build a better Nation through Quality Education with team spirit. Our students are enabled to excel in all values of Life and become Good Citizens. We continually improve the System, Infrastructure and Service to satisfy the Students, Parents, Industry and Society.

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

VISION

To inculcate discipline, good quality education, research and training, wide knowledge to meet the global standards, opportunities to gain practical knowledge in the laboratories, awareness in emerging technologies in students to render their services for the betterment of the society with ethics.

MISSION

To provide a platform in acquiring knowledge in the field of Electrical and Electronics Engineering with highest quality in technical education and services to the society. To fulfill the needs:

1. We are committed to provide best teaching and mentoring.
2. We provide outstanding education for Electrical and Electronics Engineers that prepares them for exemplary life-long career and professional growth.
3. We develop innovative methods of technologies through research that meets the needs of industry, government and the scientific community.
4. We guide our graduates to pursue their formal education further, including PG and PhD programmes.
5. We are committed to excel in student learning activities, to produce them as problem solvers as a team or individual by active interaction and effective communication with peers and clients.

AUTONOMOUS CURRICULA AND SYLLABI
Regulations 2024

SEMESTER I

S. NO	COURSE CODE	COURSE TITLE	WEEK HOURS L	T	P	TOTAL CONTACT HOURS	CREDITS
THEORY							
1	24PESMA102	Applied Mathematics For Electrical Engineers	4	0	0	4	4
2	24PPEPC101	Advanced Power Semiconductor Devices	3	0	0	3	3
3	24PPEPC102	Analysis of Electrical Machines	3	0	0	3	3
4	24PPEPC103	Analysis and Design of Power Converters	3	0	0	3	3
5	24PPEPC104	Analysis and Design of Inverters	3	0	0	3	3
6	24PPEPC105	Special Machines and Controllers	3	0	0	3	3
PRACTICAL							
7	24PPEPL101	Power Electronics Circuits Laboratory	0	0	3	3	1.5
VALUE ADDITIONS - I							
8	24PPETE101	Innovative Design Project - I	0	0	4	4	2
TOTAL						**26**	**22.5**

SEMESTER II

S. NO	COURSE CODE	COURSE TITLE	WEEK HOURS L	T	P	TOTAL CONTACT HOURS	CREDITS
THEORY							
1	24PPEPC201	Solid State AC Drives	3	0	0	3	3
2	24PPEPC202	Solid State DC Drives	3	0	0	3	3
3	24PPEELXXX	Professional Elective I	3	0	0	3	3
4	24PPEELXXX	Professional Elective II	3	0	0	3	3
5	24PPEELXXX	Professional Elective III	3	0	0	3	3
PRACTICAL							
6	24PPEPL201	Electrical Drives Laboratory	0	0	3	3	1.5
VALUE ADDITIONS - I							
7	24PPETE201	Innovative Design Project-II	0	0	4	4	2
TOTAL						**22**	**18.5**

SEMESTER III

S. NO	COURSE CODE	COURSE TITLE	WEEK HOURS L	WEEK HOURS T	WEEK HOURS P	TOTAL CONTACT HOURS	CREDITS
THEORY							
1	24PPEELXXX	Professional Elective – IV	3	0	0	3	3
2	24PPEELXXX	Professional Elective – V	3	0	0	3	3
PRACTICAL							
3	24PPEPJ301	Project Work Phase - I	0	0	12	12	6
TOTAL						**18**	**12**

SEMESTER IV

S. NO	COURSE CODE	COURSE TITLE	WEEK HOURS L	WEEK HOURS T	WEEK HOURS P	TOTAL CONTACT HOURS	CREDITS
PRACTICAL							
1	24PPEPJ401	Project Work Phase - II	0	0	24	24	12
TOTAL						**24**	**12**

PROFESSIONAL ELECTIVES - I

S. NO	COURSE CODE	COURSE TITLE	WEEK HOURS L	T	P	TOTAL CONTACT HOURS	CREDIT
1	24PPEEL201	System Theory	3	0	0	3	3
2	24PPEEL202	Soft Computing Technique	3	0	0	3	3
3	24PPEEL203	Electromagnetic Field Computation and Modeling	3	0	0	3	3
4	24PPEEL204	Control System Design for Power Electronics	3	0	0	3	3
5	24PPEEL205	Flexible AC Transmission Systems	3	0	0	3	3
6	24PPEEL206	Analog and Digital Controllers	3	0	0	3	3

PROFESSIONAL ELECTIVES - II

S. NO	COURSE CODE	COURSE TITLE	WEEK HOURS L	T	P	TOTAL CONTACT HOURS	CREDIT
1	24PPEEL207	Modern Rectifiers and Resonant Converters	3	0	0	3	3
2	24PPEEL208	MEMS Technology	3	0	0	3	3
3	24PPEEL209	Distributed Generation and Microgrid	3	0	0	3	3
4	24PPEEL210	Electric Vehicles and Power Management	3	0	0	3	3
5	24PPEEL211	Smart Grid	3	0	0	3	3
6	24PPEEL212	Solar and Energy Storage systems	3	0	0	3	3

PROFESSIONAL ELECTIVES - III

S. NO	COURSE CODE	COURSE TITLE	WEEK HOURS L	T	P	TOTAL CONTACT HOURS	CREDIT
1	24PPEEL213	High Voltage Direct Current Transmission	3	0	0	3	3
2	24PPEEL214	Power Electronics for Renewable Energy Systems	3	0	0	3	3
3	24PPEEL215	Robotics and Control	3	0	0	3	3
4	24PPEEL216	Wind Energy Conversion Systems	3	0	0	3	3
5	24PPEEL217	Power Quality Assessment and Mitigation	3	0	0	3	3
6	24PPEEL218	Non Linear Dynamics for Power Electronics Circuit	3	0	0	3	3

PROFESSIONAL ELECTIVES - IV

S. NO	COURSE CODE	COURSE TITLE	WEEK HOURS L	WEEK HOURS T	WEEK HOURS P	TOTAL CONTACT HOURS	CREDIT
1	24PPEEL301	Power Electronic Application To Power System	3	0	0	3	3
2	24PPEEL302	Digital Control For Power Electronic Applications	3	0	0	3	3
3	24PPEEL303	Simulation of Power Electronic Systems	3	0	0	3	3
4	24PPEEL304	Computer Aided Design Of Electrical Machines	3	0	0	3	3
5	24PPEEL305	Switched Mode Power Converters	3	0	0	3	3
6	24PPEEL306	Energy Management and Auditing	3	0	0	3	3

PROFESSIONAL ELECTIVES - V

S. NO	COURSE CODE	COURSE TITLE	WEEK HOURS L	WEEK HOURS T	WEEK HOURS P	TOTAL CONTACT HOURS	CREDIT
1	24PPEEL307	Electromagnetic Interference and Compatibility	3	0	0	3	3
2	24PPEEL308	Modern Automotive Systems	3	0	0	3	3
3	24PPEEL309	Advanced Energy Storage Technology	3	0	0	3	3
4	24PPEEL310	Advanced Electric Drives And Control	3	0	0	3	3
5	24PPEEL311	Advanced Control Systems	3	0	0	3	3
6	24PPEEL312	Modern Power Electronics For Traction Applications	3	0	0	3	3

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1 Graduate will apply the principles of basic science, mathematics and engineering fundamentals necessary to formulate, solve and analyze engineering problems.

PEO2 Graduate will expertise in the field of Electrical and Electronics Engineering.

PEO3 Graduate will acquire the knowledge for pursuing advanced degrees in Engineering, Science, Management, Research and Development.

PEO4 Graduate will achieve professionalism, leadership qualities, self and continuous learning.

PEO5 Graduate will fulfill the needs of the society by working as Engineers, Entrepreneurs in core as well as inter-disciplinary areas in an ethical and responsible manner.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1 Analyze, design and simulate power electronic circuits and drives in multi-disciplinary environments in order to apply technological developments for sustainable development of the society.

PSO2 Learn and apply modern software techniques and hardware implementation in power electronic control of drives to improve the knowledge and interest towards research and innovation.

PROGRAMME OUTCOMES(POs)

PO1 **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals and engineering specialization to the solution of complex engineering problems.

PO2 **Problem analysis:** Identify, formulate, review, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3 **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4 **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6 **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7 **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8 **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10 **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11 **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12 **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

SEMESTER - I

		L	T	P	C
24PESMA102 SDG NO. 4 & 9	**APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERS**	4	0	0	4

OBJECTIVES:

- To gain knowledge about various decompositions of a matrix and solve systems of equations using least squares methods.
- To know about a functional and maximizing and minimizing a functional using various given methods.
- To impart knowledge on the theory of probability and learn about some standard discrete and continuous distributions.
- To acquire knowledge on formulation and solving linear programming problems.
- To understand about Fourier transform of a function and its application in solving Partial Differential equations with initial and boundary value problems.

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 depending 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 – Bayes 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 RANDOM VARIABLES 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 – Eigenvalue problems and orthogonal functions – Regular Sturm - Liouville systems – Generalized Fourier series.

.TOTAL: 60 PERIODS

TEXT BOOKS:

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, 2nd Edition, 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 for Engineers", Pearson Education, Asia, 8th Edition, 2015.

REFERENCES:

1. O'Neil, P.V., "Advanced Engineering Mathematics", Thomson Asia Pvt. Ltd., Singapore, 2003.
2. Taha, H.A., "Operations Research, An Introduction", 9th Edition, Pearson education, New Delhi, 2016.

WEB REFERENCES:

1. https://mathworld.wolfram.com/

OUTCOMES:

Upon completion of the course, the student should be able to

1. Solve a system of linear equations that arises in engineering problems by various matrix decomposition methods.
2. Understand a functional and compute the maximum and minimum value of a functional.
3. Apply the concepts of probability, random variables, Moment generating functions, Discrete and continuous distributions in modeling real life problems.
4. To formulate a linear programming problem and Optimize using simplex method, Assignment and transportation problems.
5. Compute the solution of a Partial Differential equation by applying Fourier Transform techniques.

CO – PO, PSO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	1	-	-	-	-	-	-	1	3	3
CO2	3	3	3	2	1	-	-	-	-	-	-	1	3	3
CO3	3	3	3	2	1	-	-	-	-	-	-	1	3	3
CO4	3	3	3	2	1	-	-	-	-	-	-	1	3	3
CO5	3	3	3	2	1	-	-	-	-	-	-	1	3	3

SEMESTER - I

		L	T	P	C
24PPEPC101 **SDG NO. 4 & 9**	**ADVANCED POWER SEMICONDUCTOR DEVICES**	3	0	0	3

OBJECTIVES:

- To improve power semiconductor device structures for adjustable speed motor control applications.
- To understand the static and dynamic characteristics of current controlled power semiconductor devices
- To understand the static and dynamic characteristics of voltage-controlled power semiconductor devices
- To enable the students for the selection of devices for different power electronics applications
- To understand the control and firing circuit for different devices.

UNIT I INTRODUCTION 9

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

TEXT BOOKS:

1. David A. Bell,"Electronic devices and circuits", Oxford University higher education,5th
2. Sedra and smith, "Microelectronic circuits",7th Ed., Oxford University Press

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 Robbins, "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.

WEB REFERENCES:

1. https://www.coursera.org/lecture/converter-circuits/sect-4-2-0-introduction-to-power-semiconductors
2. https://nptel.ac.in/courses/108/105/108105066/

OUTCOMES:

Upon completion of the course, the student should be able to

1. Determine the suitable device for the application
2. Design of semiconductor device and its parameters
3. Design of protection circuits and control circuits
4. Determine the reliability of the system
5. Study thermal protection of system

CO – PO, PSO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	2	2	-	-	-	-	-	-	-	3	3
CO2	2	2	3	2	3	-	-	-	-	-	-	1	2	2
CO3	2	2	3	2	3	-	-	-	-	-	-	1	3	2
CO4	2	2	3	2	3	-	1	-	-	-	-	2	2	3
CO5	2	2	3	2	2	-	1	-	-	-	-	2	2	3

SEMESTER - I

24PPEPC102 SDG NO. 4 & 9	ANALYSIS OF ELECTRICAL MACHINES	L	T	P	C
		3	0	0	3

OBJECTIVES:

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

UNIT I PRINCIPLES OF ELECTROMAGNETIC ENERGY CONVERSION9

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 and Krons primitive machine.

TOTAL: 45 PERIODS

TEXT BOOKS:

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.

REFERENCES:

1. A.E, Fitzgerald, Charles Kingsley, Jr, and Stephan D, Umanx, " Electric Machinery", Tata McGraw Hill, 5th Edition, 1992

2. R. Krishnan, Electric Motor & Drives: Modeling, Analysis and Control, New Delhi, Prentice Hall of India, 2001

WEB REFERENCES:

1. https://onlinelibrary.wiley.com/doi/book/10.1002/9781118524336

OUTCOMES:

Upon completion of the course, the student should be able to

1. Understand the various electrical parameters in mathematical form.
2. Understand the different types of reference frame theories and transformation relationships.
3. Find the electrical machine equivalent circuit parameters
4. Understand the modelling of induction motor
5. Understand the modelling of synchronous machine

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	1	1	1	-	-	-	2	3	3	3	3	3
CO2	3	3	3	3	3	1	-	-	3	3	3	2	3	2
CO3	3	3	2	3	2	1	-	-	2	2	3	2	2	2
CO4	3	3	3	2	3	1	-	-	3	2	3	2	3	2
CO5	3	2	2	1	2	-	-	-	2	2	1	2	2	2

SEMESTER - I

24PPEPC103 SDG NO. 4 & 9	ANALYSIS AND DESIGN OF POWER CONVERTERS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To determine the operation and characteristics of controlled rectifiers.
- To apply switching techniques and basic topologies of DC-DC switching regulators.
- To introduce the design of power converter components.
- To provide an in depth knowledge about resonant converters.
- To comprehend the concept of AC-AC power converters and their applications

UNIT I SINGLE PHASE & THREE PHASE CONVERTERS 9

Principle of phase controlled converter operation – single-phase full converter and semi-converter (RL,RLE load)- single phase dual converter – Three phase operation full converter and semi-converter (R,RL,RLE load) – reactive power – power factor improvement techniques –PWM rectifiers

UNIT II DC-DC CONVERTERS 9

Limitations of linear power supplies, switched mode power conversion, Non-isolated DC-DC converters: operation and analysis of Buck, Boost, Buck-Boost, Cuk& SEPIC – under continuous and discontinuous operation – Isolated converters: basic operation of Flyback, Forward and Push-pull topologies.

.

UNIT III 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/flyback converter-selection of output filter capacitors – selection of ratings for devices – input filter design.

UNIT IV RESONANT DC-DC CONVERTERS 9

Switching loss, hard switching, and basic principles of soft switching-classification of resonant converters- load resonant converters – series and parallel – resonant switch converters – operation and analysis of ZVS, ZCS converters comparison of ZCS/ZVS-Introduction to ZVT/ZCT PWM converters.

UNIT V AC-AC CONVERTERS 9

Principle of on-off and phase angle control – single phase ac voltage controller – analysis with R & RL load – Three phase ac voltage controller – principle of operation of cyclo converter – single phase and three phase cyclo converters – Introduction to matrix converters.

TOTAL: 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

REFERENCES:

1. Simon Ang, Alejandro Oliva, “Power-Switching Converters, Second Edition, CRC Press, Taylor & Francis Group, 2010.
2. V.Ramanarayanan, “Course material on Switched mode power conversion”, 2007.
3. Alex Van den Bossche and Vencislav Jekov Valchev, “Inductors and Transformers for Power Electronics”, CRC Press, Taylor & Francis Group, 2005.
4. W. G. Hurley and W. H.Wolfle, “Transformers and Inductors for Power Electronics Theory, Design and Applications”, 2013 John Wiley & Sons Ltd.
5. Marian.K.Kazimierczuk and DariuszCzarkowski, “Resonant Power Converters”,

ONLINE RESOURCES:

1. https://nptel.ac.in/courses/108/105/108105066/

OUTCOMES:

Upon completion of the course, the student should be able to:

1. Analyze various single phase and three phase power converters
2. Select and design dc-dc converter topologies for a broad range of power conversion applications.
3. Develop improved power converters for any stringent application requirements.
4. Design ac-ac converters for variable frequency applications.
5. To provide an in depth knowledge about resonant converters.

CO- PO, PSO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	1	1	-	-	-	2	3	3	3	3	3
CO2	3	3	3	3	3	2	-	-	3	3	3	2	3	2
CO3	3	3	3	3	2	1	-	-	1	2	3	3	2	3
CO4	3	2	2	2	3	2	-	-	3	2	3	2	3	2
CO5	3	2	3	1	2	-	-	-	2	2	1	2	2	2

SEMESTER - I

24PPEPC104 SDG NO. 4 & 9	ANALYSIS AND DESIGN OF INVERTERS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To Provide the electrical circuit concepts behind the different working modes of inverters so as to enable deep understanding of their operation.
- To equip with required skills to derive the criteria for the design of inverters for UPS, drives etc.,
- To analyse and comprehend thevarious operating modes of different configurations of inverters.
- To design different single phase and three phase inverters.
- To impart knowledge on multilevel inverters and modulation techniques

UNIT I SINGLE PHASE INVERTERS 9

Principle of operation of half and full bridge inverters – Performance parameters – Voltage control of single phase inverters using various PWM techniques – various harmonic elimination techniques – forced commutated thyristor inverters

UNIT II THREE PHASE VOLTAGE SOURCE INVERTERS 9

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

UNIT III CURRENT SOURCE INVERTERS 9

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

UNIT IV MULTILEVEL & BOOST INVERTERS 9

Multilevel concept – diode clamped – flying capacitor – cascade type multilevel inverters - Comparison of multilevel inverters - application of multilevel inverters – PWM techniques for MLI – Single phase & Three phase Impedance source inverters .

UNIT V RESONANT INVERTERS AND POWER CONDITIONERS 9

Series and parallel resonant inverters - voltage control of resonant inverters –

Class E resonant inverter – resonant DC - link inverters.-power line disturbances-power conditioners-UPS: offline UPS, online UPS.

.TOTAL: 45 PERIODS

TEXT BOOKS:

1 Rashid M.H., "Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Third Edition, New Delhi, 2004.
2 Jai P.Agrawal, "Power Electronics Systems", Pearson Education, Second Edition, 2002
3 BimalK.Bose "Modern Power Electronics and AC Drives", Pearson Education, Second Edition, 2003.
4 Ned Mohan,TM Undeland and W.P Robbin, "Power Electronics: converters, Application and design" John Wiley and sons.Wiley India edition, 2006

REFERENCES:

1 Philip T. krein, "Elements of Power Electronics" Oxford University Press - 1998
2 P.C. Sen, "Modern Power Electronics", Wheeler Publishing Co, First Edition, New Delhi, 1998
3 P.S.Bimbra, "Power Electronics", Khanna Publishers, Eleventh Edition, 2003

WEB REFERENCES:

1. https://nptel.ac.in/courses/108/105/108105066/

OUTCOMES:

Upon completion of the course, the student should be able to

1. Apply voltage control and harmonic reduction techniques in inverters.
2. Develop control strategies for three phase voltage source inverters.
3. Distinguish the modes of operation of current source inverters.
4. Construct various types of multilevel inverters.
5. Design resonant inverters for various applications

CO- PO, PSO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	2	2	2	-	-	-	2	2	3	2
CO2	3	3	3	2	2	2	2	-	-	-	2	2	3	2
CO3	3	3	3	2	2	2	2	-	-	-	2	2	3	2
CO4	3	3	3	2	2	2	2	-	-	-	2	2	3	2
CO5	3	3	3	2	2	2	2	-	-	-	2	2	3	2

SEMESTER - I

24PPEPC105 SDG NO. 4 & 9	SPECIAL MACHINES AND CONTROLLERS	L	T	P	C
		3	0	0	3

OBJECTIVES:

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

UNIT I PERMANENT MAGNET BRUSHLESS DC MOTORS 9

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

UNIT II PERMANENT MAGNET SYNCHRONOUS MOTORS 9

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

UNIT III SWITCHED RELUCTANCE MOTORS 9

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

TEXT BOOKS:

1. T.J.E. Miller, "Brushless magnet and Reluctance motor drives", Claredon press, London, 1989.
2. R.Krishnan, " Switched Reluctance motor drives", CRC press, 2001.
3. T.Kenjo, "Stepping motors and their microprocessor controls", Oxford University press, New Delhi, 2000
4. T.Kenjo and S.Nagamori, "Permanent magnet and Brushless DC motors", Clarendon press, London, 1988

REFERENCES:

1. R.Krishnan, ' Electric motor drives' , Prentice hall of India,2002.
2. D.P.Kothari and I.J.Nagrath, ' Electric machines', Tata Mc Graw hill publishing company, New Delhi, Third Edition, 2004.
3. Irving L.Kosow, "Electric Machinery and Transformers" Pearson Education, Second Edition, 2007.

WEB REFERENCES:

1. https://nptel.ac.in/courses/108105017/
2. https://www.emerald.com/insight/content/doi/10.1108/COMPEL-12-2015-0467/full/html

OUTCOMES:

Upon completion of the course, the student should be able to

1. Understand the construction and operation of special electrical Machines
2. Analyze the characteristics of different special electrical machines
3. Distinguish the power controllers of special electrical machines
4. Utilize the principle of special electrical machines with various control technique
5. Explore a different special electrical machines with appropriate applications

CO- PO, PSO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	2	2	2	-	-	-	2	2	3	2
CO2	3	3	3	2	2	2	2	-	-	-	2	2	3	2
CO3	3	3	3	2	2	2	2	-	-	-	2	2	3	2
CO4	3	3	3	2	2	2	2	-	-	-	2	2	3	2
CO5	3	3	3	2	2	2	2	-	-	-	2	2	3	2

SEMESTER - I

		L	T	P	C
24PPEPL101 **SDG NO. 4,9&12**	**POWER ELECTRONIC CIRCUITS LABORATORY**	**0**	**0**	**3**	**1.5**

OBJECTIVES:

- To make the students capable of implementing analog interfacing as well as control circuits used in a closed-loop control for power electronic systems.
- To make the students acquire knowledge on mathematical modeling of power electronic circuits and implementing the same using simulation tools.
- To facilitate the students to power converter circuits at appreciable voltage/power levels.
- To introduce students to industrial control of power electronic circuits as well as safe electrical connection and measurement practices.
- To develop skills on PCB design and fabrication among the students.

LIST OF EXPERIMENTS

1. Modeling and System Simulation of SCR based full converter with different types of load using MATLAB-Simulink/SCILAB
   a) Full converter fed resistive load
   b) Full converter fed Resistive-Back Emf (RE) load at different firing angles
   c) Full Converter fed Resistive-Inductive Load at different firing angles
   d) Full converter fed DC motor load at different firing angles
2. Circuit Simulation of Voltage Source Inverter and study of spectrum analysis with and without filter using MATLAB/SCILAB
   a) Single phase square wave inverter
   b) Three phase sine PWM inverter

3. Generation of PWM gate pulses with duty cycle control using PWM peripheral of microcontroller (TI-C2000 family/ PIC18)
4. Generation of Sine-PWM pulses for a three phase Voltage Source Inverter with control of modulation index using PWM peripheral of microcontroller (TI C2000 family/PIC 18)
5. Design of PI controller.
6. Design of 500 W, 220 V Buck converter with control circuit and its performance evaluation.
7. Design of 500 W, 220 V Boost converter with control circuit and its performance evaluation.
8. PCB design and fabrication of DC power supply using any PCB design software (open source- KiCAD/students version)
9. Simulation of Multi-level inverter.

TOTAL: 45 PERIODS

OUTCOMES:

Upon completion of the course, the student should be able to

1. Comprehensive understanding on mathematical modeling of power electronic system and ability to implement the same using simulation tools
2. Ability of the student to design and implement analog circuits for Power electronic control applications
3. Ability to design and fabricate a power converter circuit at an reasonable power level
4. Realize the limitations of computer simulations for verification of circuit behavior, apply these techniques to different power electronic circuits and evaluate possible causes of discrepancy in practical experimental observations in comparison to theory.
5. Exposure to PCB designing and fabrication.

CO- PO, PSO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	2	2	2	-	-	-	2	2	3	2
CO2	3	3	3	2	2	2	2	-	-	-	2	2	3	2
CO3	3	3	3	2	2	2	2	-	-	-	2	2	3	2
CO4	3	3	3	2	2	2	2	-	-	-	2	2	3	2
CO5	3	3	3	2	2	2	2	-	-	-	2	2	3	2

SEMESTER - I

24PPETE101 SDG NO. 4,7,8,9,11,12	INNOVATIVE DESIGN PROJECT-I	L	T	P	C
		0	0	4	2

OBJECTIVES:

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

METHODOLOGY:

1. Student should do it individually.
2. Student should submit / present his/her ideas to the Faculty-in-Charge for approval.
3. Student should submit proposal with system/ technical details and cost implications.
4. Student should periodically demonstrate his/her progress.

EVALUATION:

Evaluation will be based on:

1. The social relevance of the work.
2. The utility of the system developed.
3. The Level of proof of concept.
4. Industry support if obtained.etc.

WEB REFERENCES:

1. https://www.mathworks.com/academia/books.html
2. http://www.mathcs.emory.edu/~cheung/Courses/455/Syllabus/A3-NS/Book/Introduction-to-Network-Simulator-NS2-2012.pdf

ONLINE REFERENCES

1. http://www.jgyan.com/ns2/
2. https://matlabacademy.mathworks.com/

OUTCOMES:

Upon completion of the course, the student should be able to

1. Acquire practical knowledge within the chosen area of technology for project development.
2. Identify, analyze, formulate and handle programming projects with a comprehensive and systematic approach.
3. Contribute as an individual or in a team in development of technical projects.
4. Develop effective communication skills for presentation of project related activities.
5. Ability to work and coordinate with team members.

CO - PO - PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	3	1	-	-	-	-	-	-	-	-	3	2
CO2	1	1	2	2	-	-	-	-	-	-	-	-	2	2
CO3	1	3	2	1	-	-	1	-	-	-	1	1	2	3
CO4	1	1	1	3	1	-	-	1	-	1	1	1	3	2
CO5	1	1	2	2	-	1	-	1	-	-	1	1	2	2

SEMESTER - II

24PPEPC201 SDG NO. 4	SOLID STATE AC DRIVES	L	T	P	C
		3	0	0	3

OBJECTIVES:

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

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 FORCE, MAGNETIC AND HEADING SENSORS 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

TEXT BOOKS:

1. Bimal K Bose, "Modern Power Electronics and AC Drives", Pearson Education Asia 2002.
2. 2.Vedam Subramanyam, "Electric Drives – Concepts and Applications", Tata McGraw Hill, 1994.
3. 3Gopal K Dubey, "Power Semiconductor controlled Drives", Prentice Hall Inc.,New Jersey, 1989

REFERENCES:

1. R.Krishnan, "Electric Motor Drives – Modeling, Analysis and Control", Prentice-Hall of India Pvt. Ltd., New Delhi, 2003.
2. W.Leonhard, "Control of Electrical Drives", Narosa Publishing House, 1992.
3. Murphy J.M.D and Turnbull, "Thyristor Control of AC Motors", Pergamon Press, Oxford, 1988.

WEB RESOURCES

1. https:// www.electrical4u.com / induction-motor-braking
2. https:// www.electrical4u.com / field-oriented-control
3. https://www.allaboutcircuits.com/textbook/alternating-current/chpt-13/synchronous-motors/

OUTCOMES:

Upon completion of the course, the student should be able to

1. Acquire knowledge about the steady state performance of induction motors and their braking methods.
2. Understand the concepts of various schemes of VSI and CSI fed induction drives and their comparison.
3. Knowledge about the static scherbius and Kramer drives of Induction motors
4. Awareness about the field oriented control and direct torque control of Induction machines
5. Knowledge about the starting , braking,control and excitation schemes of synchronous motor drives.

CO-PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	-	1	1	-	-	1	-	-	-	2	1
CO2	1	1	2	2	2	1	-	-	1	-	1	-	3	3
CO3	1	1	3	2	3	2	1	-	-	-	1	-	2	1
CO4	2	2	2	-	1	-	1	-	-	-	1	1	2	2
CO5	1	1	2	2	1	-	1	-	1	-	1	1	3	3

SEMESTER - II

24PPEPC202 SDG NO. 4 & 9	SOLID STATE DC DRIVES	L	T	P	C
		3	0	0	3

OBJECTIVES:

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

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 free wheeling 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

Modeling of drive elements – Equivalent circuit, transfer function of self, separately excited DC motors; Linear Transfer function model of power converters; Sensing and feedback 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 horsepower and load disturbed operations; Speed detection and current sensing circuits.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Bimal K Bose, "Modern Power Electronics and AC Drives", Pearson Education Asia 2002.
2. 2.Vedam Subramanyam, "Electric Drives – Concepts and Applications", Tata McGraw Hill, 1994.
3. 3Gopal K Dubey, "Power Semiconductor controlled Drives", Prentice Hall Inc.,New Jersey, 1989.

REFERENCES:

1. R.Krishnan, "Electric Motor Drives – Modeling, Analysis and Control", Prentice-Hall of India Pvt. Ltd., New Delhi, 2003.
2. W.Leonhard, "Control of Electrical Drives", Narosa Publishing House, 1992.
3. Murphy J.M.D and Turnbull, "Thyristor Control of AC Motors", Pergamon Press, Oxford, 1988.

WEB RESOURCES:

1. http://www.industrial-electronics.com/ind-mtr-cntrl_034.html

2. https://nptel.ac.in/courses/108108077/
3. https://link.springer.com/content/pdf/bfm%3A978-0-387-48598-0%2F1.pdf

OUTCOMES:

Upon completion of the course, the student should be able to

1. Explain the fundamental operation and basic speed control of DC drives.
2. Analyse the performance of converter and chopper controlled DC drives in different quadrants.
3. Calculate the performance parameter of converter and chopper controlled DC drives.
4. Apply the closed loop and digital control scheme for DC drives.
5. Understand the various applications of DC drives2.Understand the concepts of various schemes of VSI and CSI fed induction drives and their comparison.

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	1	-	1	-	-	-	-	-	1	-	1	1
CO2	2	-	2	1	-	2	1	-	1	1	2	-	1	2
CO3	3	3	3	3	3	2	1	-	1	2	1	1	3	3
CO4	2	2	3	3	3	1	1	-	2	2	2	2	3	3
CO5	2	3	3	3	3	2	1	1	2	2	3	3	3	3

SEMESTER - II

24PPEPL201 SDG NO. 4	ELECTRICAL DRIVES LABORATORY	L	T	P	C
		0	0	3	1.5

OBJECTIVES:

- To understand the basic concepts of Electric drives and their analysis with strong engineering knowledge and technical competence
- To explore the performance of power converter fed drives by using simulation software microcontroller and DSP controllers
- To generate the firing pulses for converters and inverters using digital processors
- Implementation of closed loop system using hardware simulation
- To evaluate the use of computer-based analysis tools to review the major classes of machines and their physical basis for operation

LIST OF EXPERIMENTS:

1. Speed control of Converter fed DC motor.
2. Speed control of Chopper fed DC motor.
3. V/f control of a three-phase induction motor.
4. Micro controller based speed control of Stepper motor.
5. DSP based Speed control of BLDC motor.
6. DSP based speed control of Switched Reluctance motor.
7. Voltage Regulation of three-phase Synchronous Generator.
8. Speed control of Permanent Magnet Synchronous Motor.
9. Speed control of BLDC motor using Matlab.
10. Design of Switched Reluctance motor using MAGNET / MOTORSOLVE.

TOTAL: 45 PERIODS

OUTCOMES:

Upon completion of the course, the student should be able to

1. Students would be able to understand the basic characteristics of an electric motor drive.
2. Combine the use of computer-based simulation tools relevant to electrical Drives with practical laboratory experimentation..
3. Students would be able to design an open loop based system as well as a closed loop system for any electrical drive for controlling the speed and other relevant parameters efficiently.

4. Students would be able to understand the criterion behind the selection of a particular motor for any particular application.
5. Ensure Energy Efficient operation of drives.

CO- PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	3	1	-	-	-	-	-	-	-	-	3	2
CO2	1	1	2	2	-	-	-	-	-	-	-	-	2	2
CO3	1	3	2	1	-	-	1	-	-	-	1	1	2	3
CO4	1	1	1	3	1	-	-	1	-	1	1	1	3	2
CO5	1	1	2	2	-	1	-	1	-	-	1	1	2	2

SEMESTER - II

24PPETE201 SDG NO. 4,7,8,9,11,12	INNOVATION DESIGN PROJECT-II	L	T	P	C
		0	0	4	2

OBJECTIVES:

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

METHODOLOGY:

1. Student should do it individually.
2. Student should submit / present his/her ideas to the Faculty-in-Charge for approval.
3. Student should submit proposal with system/ technical details and cost implications.
4. Student should periodically demonstrate his/her progress.

EVALUATION:

Evaluation will be based on:

1. The social relevance of the work.
2. The utility of the system developed.
3. The Level of proof of concept.
4. Industry support if obtained etc.

WEB REFERENCES:

1. https://www.mathworks.com/academia/books.html
2. http://www.mathcs.emory.edu/~cheung/Courses/455/Syllabus/A3-NS/Book/Introduction-to- Network-Simulator-NS2-2012.pdf

ONLINE REFERENCES:

1. http://www.jgyan.com/ns2/
2. https://matlabacademy.mathworks.com/

OUTCOMES:

Upon completion of the course, the student should be able to

1. Acquire practical knowledge within the chosen area of technology for project development
2. Identify, analyze, formulate and handle programming projects with a comprehensive and systematic approach
3. Contribute as an individual or in a team in development of technical projects
4. Develop effective communication skills for presentation of project related activities
5. Ability to work and coordinate with team members

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	3	1	-	-	-	-	-	-	-	-	3	2
CO2	1	1	2	2	-	-	-	-	-	-	-	-	2	2
CO3	1	3	2	1	-	-	1	-	-	-	1	1	2	3
CO4	1	1	1	3	1	-	-	1	-	1	1	1	3	2
CO5	1	1	2	2	-	1	-	1	-	-	1	1	2	2

SEMESTER - III

24PPEPJ301 SDG NO. 4,7,8,9,11,12	PROJECT WORK PHASE - I	L	T	P	C
		0	0	12	6

OBJECTIVES:

- To identify a specific problem for the current need of the society and collecting information related to the same through detailed review of literature.
- To develop the methodology to solve the identified problem.

SYLLABUS:

The student individually works on a specific topic approved by the head of the division under the guidance of a faculty member who is familiar in this area of interest. The student can select any topic which is relevant to the area of engineering design. The topic may be theoretical or case studies. At the end of the semester, a detailed report on the work done should be submitted which contains clear definition of the identified problem, detailed literature review related to the area of work and methodology for carrying out the work. The students will be evaluated through a viva-voce examination by a panel of examiners including one external examiner.

TOTAL: 180 PERIODS

OUTCOMES :

Upon completion of the course, the students should be able to

1. Conceptualize the societal needs and acquire exposure to product development.
2. Get familiarized with respect to design standards, design calculations and analysis in designing any mechanical component or system.
3. Get clear idea of their area of work and they will be in a position to carry out the remaining phase II work in a systematic way.

CO-PO & PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	3	2	3	3	3	3	3	3	3	3
CO2	2	2	3	1	3	3	3	3	3	3	3	3	3	3
CO3	3	1	-	-	3	-	2	3	3	3	1	3	3	3

SEMESTER - IV

24PPEPJ401 SDG NO. 4,7,8,9,11,12	PROJECT WORK PHASE - II	L	T	P	C
		0	0	24	12

OBJECTIVES:

- To solve the identified problem based on the formulated methodology.
- To develop skills to analyze and discuss the test results, and make conclusions

SYLLABUS:

The student should continue the phase I work on the selected topic as per the formulated methodology under the same supervisor. At the end of the semester, after completing the work to the satisfaction of the supervisor and review committee, a detailed report should be prepared and submitted to the head of the department. The students will be evaluated based on the report submitted and the viva-voce examination by a panel of examiners including one external examiner

TOTAL: 180 PERIODS

OUTCOMES :

Upon completion of the course, the students should be able to

1. Develop project related to societal needs and acquire knowledge regarding product development.
2. Get familiarized with respect to design standards, design calculations and analysis in designing any mechanical component or system.
3. Take up any challenging practical problem in the field of engineering design and find better solutions to it.

CO-PO & PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	3	2	3	3	3	3	3	3	3	3
CO2	2	2	3	1	3	3	3	3	3	3	3	3	3	3
CO3	3	1	-	-	3	-	2	3	3	3	1	3	3	3

PROFESSIONAL ELECTIVES - I

24PPEEL201 SDG NO. 4	SYSTEM THEORY	L	T	P	C
		3	0	0	3

OBJECTIVES:

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

UNIT I STATE VARIABLE REPRESENTATION 9

Introduction-Concept of State-State 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 Eigenvalues and Eigenvectors.

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 STABILITY 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-Gradient Method.

TOTAL: 45 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.

REFERENCES:

1 John J. D'Azzo, C. H. Houpis and S. N. Sheldon, "Linear Control System Analysis and

2 Design with MATLAB", Taylor Francis, 2003.

3 Z. Bubnicki, "Modern Control Theory", Springer, 2005.

4 C.T. Chen, "Linear Systems Theory and Design'' Oxford University Press, 3rd Edition, 1999.

5 M. Vidyasagar, "Nonlinear Systems Analysis', 2nd edition, Prentice Hall, Englewood Cliffs, New Jersey.

WEB REFERENCES:

1. https://nptel.ac.in/courses/108106150/
2. https://swayam.gov.in/nd1_noc19_ee43/preview

OUTCOMES:

Upon completion of the course, the student should be able to

1. Ability to represent the time-invariant systems in state space form as well as analyze, whether the system is stabilizable, controllable, observable and detectable.

2. Ability to design state feedback controller and state observers
3. Ability to classify singular points and construct phase trajectory using Delta and isocline methods.
4. Use techniques such as describing function, Lyapunov Stability, Popov's Stability Criterion and Circle Criterion to assess the stability of a certain class of nonlinear system.
5. Ability to describe non-linear behaviors such as Limit cycles, input multiplicity and output multiplicity, Bifurcation and Chaos.

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	1	2	-	-	-	1	1	1	2	2	2
CO2	3	3	3	2	3	-	-	-	1	1	1	2	3	2
CO3	3	3	3	3	3	-	-	-	2	2	1	2	3	3
CO4	3	2	3	2	2	-	-	-	1	2	1	2	2	2
CO5	3	3	3	2	3	-	-	-	1	2	1	2	3	3

PROFESSIONAL ELECTIVES - I

24PPEEL202 SDG NO. 4	SOFT COMPUTING TECHNIQUE	L	T	P	C
		3	0	0	3

OBJECTIVES:

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

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 feedforward 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 backpropagation training- applications.

UNIT II ARTIFICIAL NEURAL NETWORKS AND ASSOCIATIVE MEMORY 9

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

UNIT III FUZZY LOGIC SYSTEM 9

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

UNIT IV GENETIC ALGORITHM 9

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

UNIT V HYBRID CONTROL SCHEMES 9

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

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Laurene V. Fausett, "Fundamentals of Neural Networks: Architectures, Algorithms And Applications", Pearson Education.

2. Timothy J. Ross, "Fuzzy Logic with Engineering Applications" Wiley India, 2008.
3. Zimmermann H.J. "Fuzzy set theory and its Applications" Springer international edition, 2011.
4. David E.Goldberg, "Genetic Algorithms in Search, Optimization, and Machine Learning", Pearson Education, 2009

REFERENCES:

1. W.T.Miller, R.S.Sutton and P.J.Webrose, "Neural Networks for Control" MIT Press", 1996
2. T. Ross, "Fuzzy Logic with Engineering Applications", Tata McGraw Hill, New Delhi, 1995.
3. Ethem Alpaydin, "Introduction to Machine Learning (Adaptive Computation and Machine Learning Series)", MIT Press, 2004.
4. Corinna Cortes and V. Vapnik, " Support - Vector Networks, Machine Learning " 1995Prentice Hall, Englewood Cliffs, New Jersey.

WEB REFERENCES:

1. https://nptel.ac.in/courses/106105173/
2. https://www.classcentral.com/course/swayam-introduction-to-soft-computing-10053

OUTCOMES:

Upon completion of the course, the student should be able to

1. Will be able to know the basic ANN architectures, algorithms and their limitations.Also will be able to know the different operations on the fuzzy sets.
2. Will be capable of developing ANN based models and control schemes for nonlinear systems.
3. Will get expertise in the use of different ANN structures and online training algorithms.
4. Will be knowledgeable to use Fuzzy logic for modeling and control of non-linear systems.
5. Will be competent to use hybrid control schemes and P.S.O and support vector Regressive.

CO-PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	3	1	1	-	-	-	1	1	1	1	1	1
CO2	2	2	2	2	2	-	-	-	1	1	1	1	2	1
CO3	2	3	3	3	3	1	-	-	2	2	2	3	3	3
CO4	2	3	3	3	3	1	-	-	2	2	2	3	2	3
CO5	2	3	3	2	3	1	-	-	1	2	1	3	3	3

PROFESSIONAL ELECTIVES - I

24PPEEL203 SDG NO. 4	ELECTROMAGNETIC FIELD COMPUTATION AND MODELING	L	T	P	C
		3	0	0	3

OBJECTIVES:

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

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

TEXT BOOKS:

1. Matthew. N.O. Sadiku, "Elements of Electromagnetics", Fourth Edition, Oxford University Press, First Indian Edition, 2007.
2. 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. 3.Nicola Biyanchi , "Electrical Machine analysis using Finite Elements", Taylor and Francis Group, CRC Publishers, 2005.

REFERENCES:

1. Nathan Ida, Joao P.A. Bastos, "Electromagnetics and calculationof fields", Springer Verlag, 1992.
2. S.J Salon, "Finite Element Analysis of Electrical Machines" Kluwer Academic Publishers, London, 1995, distributed by TBH Publishers & Distributors, Chennai, India
3. Silvester and Ferrari, "Finite Elements for Electrical Engineers" Cambridge University press, 1983.

WEB REFERENCES:

1. https://interferencetechnology.com/electromagnetic-interference-sources-and-their-most-significant-effects.
2. https://en.m.wikipedia.org/wiki/Electromagnetic_interference.
3. https://www.herzan.com/resources/applications/noise-source/electromagnetic-interference.html.

OUTCOMES:

Upon completion of the course, the student should be able to

1. Acquire the concepts of buck converter and mathematical model for Power Electronics Devices.
2. Ability in designing the sliding mode controllers using buck, boost, zeta and buck-boost converters.
3. Exposed knowledge in approximate linearization controller design.

4. Describe the skills required to design the nonlinear controller.
5. Explain operation, characteristics and performance parameters of predictive control in power Converters and control of nonlinear systems.

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	-	-	3	-	-	-	-	-	3	3	3
CO2	3	3	1	-	-	3	-	-	-	-	-	3	3	3
CO3	3	3	2	-	-	2	-	-	-	-	-	3	2	2
CO4	3	3	2	-	-	3	-	-	-	-	-	3	2	2
CO5	3	3	1	-	-	3	-	-	-	-	-	3	3	3

PROFESSIONAL ELECTIVES - I

24PPEEL204 SDG NO. 4	CONTROL SYSTEM DESIGN FOR POWER ELECTRONICS	L	T	P	C
		3	0	0	3

OBJECTIVES:

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

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 SurfaceSliding 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 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

TEXT BOOKS:

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.

REFERENCES:

1. Enrique Acha, VassiliosAgelidis, Olimpo Anaya, TJE Miller, "Power Electronic Control in Electrical Systems", Newnes, 2002
2. Marija D. Aranya Chakrabortty, Marija , "Control and Optimization Methods for Electric Smart Grids", Springer, 2012.

WEB REFERENCES:

1. https://nptel.ac.in/courses/108106150
2. https://swayam.gov.in/nd1_noc19_ee43/preview

OUTCOMES:

Upon completion of the course, the student should be able to

1. Recall the basics concepts in magnetic field theory.
2. Describe the skills required to give the solutions for field equation.

3. Develop the finite element methods in one dimensional and two dimensional analysis.
4. Evaluating the energy stored in Electric and magnetic fields.
5. Apply the concepts of field fundamentals for the equipments to design the insulator, transformer and rotating machines.

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	3	2	3	-	-	-	-	-	3	3	3
CO2	3	3	1	2	3	3	-	-	-	-	-	3	3	3
CO3	3	3	2	3	2	2	-	-	-	-	-	3	2	2
CO4	3	3	2	2	3	3	-	-	-	-	-	3	2	2
CO5	3	3	3	2	3	3	-	-	-	-	-	3	3	3

PROFESSIONAL ELECTIVES - I

24PPEEL205 SDG NO. 4	FLEXIBLE AC TRANSMISSION SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To emphasize the need for FACTS controllers.
- To learn the characteristics, applications and modelling of series and shunt FACTS controllers.
- To analyze the interaction of different FACTS controller and perform control coordination

UNIT I INTRODUCTION 9

Review of basics of power transmission networks-control of power flow in AC transmission lineAnalysis of uncompensated AC Transmission line- Passive reactive power compensation: Effect of series and shunt compensation at the midpoint 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 of a SMIB system- Applications: transient stability enhancement and power oscillation damping of SMIB system with SVC connected at the midpoint of the line.

UNIT III THYRISTOR AND GTO THYRISTOR CONTROLLED SERIES CAPACITORS TCSC and GCSC) 9

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

UNIT IV VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS9

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 - coordination of multiple controllers using linear control techniques – Quantitative treatment of control coordination.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. S.T.John, "Flexible AC Transmission System", Institution of Electrical and Electronic Engineers (IEEE), 1999.
2. NarainG.Hingorani, Laszio. Gyugyi, "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.

REFERENCES:

1. Patranabis D, "Sensors and Transducers", 2nd Edition, PHI, New Delhi, 2010.
2. John Turner and Martyn Hill, "Instrumentation for Engineers and Scientists", Oxford Science Publications, 1999.
3. Richard Zurawski, "Industrial Communication Technology Handbook" 2nd edition, CRC Press, 2015.

WEB REFERENCES:

1. https://nptel.ac.in/courses/108107114/
2. http://engineering.electrical-equipment.org/power-quality/flexible-alternating-current-transmission-system-facts.html

OUTCOMES :

Upon completion of the course, the student should be able to

1. Understand the operation of the compensator and its applications in the power system.
2. Understand the modeling, operation and control strategies of Static Var Compensation-SVC.
3. Understand the concept of series compensation and modeling, operation and control strategies of TCSC and GCSC.
4. Understand the voltage source based FACTS controllers.
5. Know the FACTS Controller interactions and Coordinating multiple FACTS controllers using control techniques.

CO- PO,PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	2	1	-	-	-	1	2	1	2	2	2
CO2	3	3	3	3	2	-	-	-	1	2	1	3	3	3
CO3	3	3	3	3	2	-	-	-	1	2	1	2	2	3
CO4	3	3	3	3	2	-	-	-	1	2	1	3	3	2
CO5	2	2	2	2	1	-	-	-	1	2	1	2	2	3

PROFESSIONAL ELECTIVES - I

24PPEEL206 SDG NO. 4	ANALOG AND DIGITAL CONTROLLERS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To provide an overview of the control system and converter control methodologies.
- To provide an insight to the analog controllers generally used in practice
- To introduce Embedded Processors for Digital Control
- To study on the driving techniques, isolation requirements, signal conditioning and protection methods

- To provide a Case Study by implementing an analog and a digital controller on a Converter
- To involve Discussions/ Practice/Exercise onto revising & familiarizing the concepts acquired over the 5 Units of the subject for improved employability skills

UNIT I CONTROL SYSTEM OVERVIEW 9

Basics of measurement 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

TEXT BOOKS:

1. Ernest O Doebelin, "Measurement Systems – Applications and Design", Tata McGraw-Hill, 2009. 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.

OUTCOMES:

Upon completion of the course, the student should be able to

1. Understand the control system and converter control methodologies.
2. Understand an insight to the analog controllers generally used in practice.
3. Understand the analysis of Embedded Processors for Digital Control.
4. Understand model and the driving technique isolation requirements, signal conditioning and protection methods.
5. Understand a Case Study by implementing an analog and a digital controller on a Converter.

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	2	-	-	-	-	-	-	1	2	2	2
CO2	2	2	2	2	2	-	-	-	-	-	1	2	2	2
CO3	2	2	2	1	1	-	-	-	-	-	-	1	2	2
CO4	2	2	1	2	1	-	-	-	-	-	2	1	2	3
CO5	2	3	3	2	2	-	-	-	-	-	1	2	2	3

PROFESSIONAL ELECTIVES - II

		L	T	P	C
24PPEEL207 **SDG NO. 4**	**MODERN RECTIFIERS AND RESONANT CONVERTERS**	**3**	**0**	**0**	**3**

OBJECTIVES:

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

UNIT I POWER SYSTEM HARMONICS & LINE COMMUTATED RECTIFIERS INTRODUCTION 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 of full wave rectifier for large and small values of capacitance - CCM and DCM operation of three phase full wave rectifier- 12 pulse converters - Harmonic trap filters.

UNIT 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 of ZVS and ZCS- half wave and full wave operation (qualitative treatment) - multi resonant converters - operation and analysis of ZVS and ZCS multi resonant converter - zero voltage transition PWM converters -zero current transition PWM converters

UNIT IV DYNAMIC ANALYSIS OF SWITCHING CONVERTERS 9

Review of linear system analysis-State Space Averaging-Basic State Space Average Model- StateSpace Averaged model for an ideal Buck Converter, ideal Boost Converter, ideal Buck BoostConverter 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

TEXT BOOKS:

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", MarceldEkkerin,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.

REFERENCES:

1. Marian.K.Kazimierczuk and DariuszCzarkowski, "Resonant Power Converters", John Wiley & Sons limited,2011.
2. KengC .Wu, "Switch Mode Power Converters – Design and Analysis" Elseveir academic press,2006.
3. Abraham I.Pressman, Keith Billings and Taylor Morey, " Switching Power Supply Design" McGraw-Hill,2009
4. V.Ramanarayanan, "Course Material on Switched Mode Power Conversion" IISC, Banglore, 2007.
5. Christophe P. Basso, Switch-Mode Power Supplies, McGraw-Hill,2014.

OUTCOMES:

Upon completion of the course, the student should be able to:

1. Understand various types of rectifiers.
2. Understand, simulate and design the operation of a resonant converter and its importance.
3. UnderstandIdentify the importance of linear system, state space model, Picontroller.
4. Understand model and Design the DC power supplies using advanced techniques.

5. Understand the standards for supply current harmonics and its significance.

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	2	-	-	-	-	-	-	1	2	2	2
CO2	2	2	2	2	2	-	-	-	-	-	1	2	2	2
CO3	2	2	2	1	1	-	-	-	-	-	-	1	2	2
CO4	2	2	1	2	1	-	-	-	-	-	2	1	2	3
CO5	2	3	3	2	2	-	-	-	-	-	1	2	3	3

PROFESSIONAL ELECTIVES - II

24PPEEL208 SDG NO. 4	MEMS TECHNOLOGY	L	T	P	C
		3	0	0	3

OBJECTIVES:

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

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

Piezoresistive sensors, Magnetic actuation, Microfluidics applications, Medical applications, Optical MEMS.-NEMS Devices

Note: Classroom 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

TEXT BOOKS:

1. Chang Liu, “Foundations of MEMS”, Pearson International Edition, 2006.
2. Marc Madou, “Fundamentals of microfabrication”, CRC Press, 1997.

REFERENCES:

1. Boston, “Micro machined Transducers Sourcebook”, WCB McGraw Hill,1998.
2. M.H.Bao “Micromechanical transducers :Pressure Sensors, accelerometers and gyroscopes”, Elsevier, Newyork,2000.

WEB REFERENCES:

1. https://www.memsnet.org/links/
2. https://www.memsnet.org/mems/what_is.html

OUTCOMES:

Upon completion of the course, the student should be able to

1. Understand basics of microfabrication, develop models and simulate electrostatic and electromagnetic sensors and actuators
2. Understand material properties important for MEMS system performance, analyze dynamics of resonant micromechanical structures
3. The learning process delivers insight into the design of micro sensors, embedded sensors & actuators in power aware systems like grid.
4. Understand the design process and validation for MEMS devices and systems, and learn the state of the art in optical micro systems

5. Improved Employability and entrepreneurship capacity due to knowledge upgradation on recent trends in embedded systems design.

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	-	2	2	1	-	-	-	1	2	2
CO2	2	3	3	2	-	-	-	1	-	-	-	1	2	1
CO3	3	-	2	-	-	-	-	-	-	-	-	1	1	2
CO4	-	-	3	-	1	1	-	-	-	-	-	-	2	1
CO5	-	2	-	2	1	1	-	-	-	-	-	-	1	1

PROFESSIONAL ELECTIVES - II

24PPEEL209 SDG NO. 4	DISTRIBUTED GENERATION AND MICROGRID	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To illustrate the concept of distributed generation
- To analyze the impact of grid integration.
- To study concept of Microgrid and its configuration

UNIT I INTRODUCTION **9**

Conventional power generation: advantages and disadvantages, Energy crises, Non- conventional 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 microgrid, microgrid drivers and benefits, review of sources of microgrids, typical structure and configuration of a microgrid, AC and DC microgrids, Power Electronics interfaces in DC and AC microgrids.

UNIT V CONTROL AND OPERATION OF MICROGRID 9

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

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Amirnaser Yazdani, 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 PhotoVoltaics", PHI learning Pvt. Ltd., NewDelhi, 2009.

REFERENCES:

1. J.F. Manwell, J.G. McGowan "Wind Energy Explained, theory design and applications", Wiley publication2010.
2. D. D. Hall and R. P. Grover, "Biomass Regenerable Energy", John Wiley, New York, 1987.
3. John Twidell and Tony Weir, "Renewable Energy Resources" Tyalor and Francis Publications, Second edition 2006.

WEB REFERENCES:

1. https://nptel.ac.in/courses/108108034/
2. https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/108107143/lec1.pdf
3. https://swayam.gov.in/nd1_noc19_ee63/preview

OUTCOMES:

Upon completion of the course, the student should be able to

1. Learners will attain knowledge on the various schemes of conventional and nonconventional power generation.
2. Learners will have knowledge on the topologies and energy sources of distributed generation.

3. Learners will learn about the requirements for grid interconnection and its impact with NCE sources
4. Learners will understand the fundamental concept of Microgrid

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	1	1	1	-	3	-	-	-	-	1	2	2
CO2	3	2	2	3	2	-	3	-	-	3	2	3	3	3
CO3	2	3	3	2	3	-	-	-	1	2	3	2	2	3
CO4	2	2	3	3	2	-	-	-	-	3	2	3	3	2
CO5	2	3	3	3	2	-	-	-	-	2	3	3	2	3

PROFESSIONAL ELECTIVES - II

24PPEEL210 SDG NO. 4,9&12	ELECTRIC VEHICLES AND POWER MANAGEMENT	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the concept of electrical vehicles and its operations
- To understand the need for energy storage in hybrid vehicles
- To provide knowledge about various possible energy storage technologies that can be used in electric

UNIT I ELECTRIC VEHICLES AND VEHICLE MECHANICS 9

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

UNIT II ARCHITECTURE OF EV's AND POWERTRAIN COMPONENT 9

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

UNIT III CONTROL OF DC AND AC DRIVES 9

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

UNIT IV BATTERY ENERGY STORAGE SYSTEM 9 Battery Basics-Different types-Battery Parameters-Battery modeling-Traction Batteries.

UNIT V ALTERNATIVE ENERGY STORAGE SYSTEM 9

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

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Iqbal Hussain, "Electric and Hybrid Vehicles: Design Fundamentals, Second Edition" CRC Press, Taylor & Francis Group, Second Edition(2011).
2. Ali Emadi, Mehrdad Ehsani, John M.Miller, "Vehicular Electric Power Systems", Special Indian Edition, Marcel dekker, Inc2010.

WEB RESOURCES:

1. https://nptel.ac.in/courses/108/103/108103009/
2. https://en.wikipedia.org/wiki/Electric_vehicle
3. https://www.eetimes.com/high-efficiency-power-management-for-electric-vehicles/#
4. https://www.energy.gov/eere/electricvehicles/electric-vehicle-basics

OUTCOMES:

Upon completion of the course, the student should be able to

1. Understand the operation of Electric vehicles and various energy storage technologies for electrical vehicles.
2. Describe about working principle of electric vehicles.
3. Choose a suitable drive scheme for developing an electric hybrid vehicle depending on resources.
4. Choose proper energy storage systems for vehicle applications .
5. Illustrate the various types and working principles of fuel cells.

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	3	3	-	-	-	1	1	3	3	3
CO2	3	3	3	3	2	2	-	-	-	1	1	2	3	3
CO3	3	3	3	3	2	2	-	-	-	1	1	2	3	3
CO4	3	3	3	3	2	3	-	-	-	1	1	2	1	3
CO5	3	3	2	2	2	1	-	-	-	1	1	2	1	1

PROFESSIONAL ELECTIVES - II

24PPEEL211 SDG NO. 4,9&11	SMART GRID	L	T	P	C
		3	0	0	3

OBJECTIVES:

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

UNIT I INTRODUCTION TO SMART GRID 9

Evolution of Electric Grid – Concept - Definitions and Need for Smart Grid-Smart grid drivers – functions – opportunities - challenges and benefits-Difference between conventional & Smart Grid- 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 GRID APPLICATIONS 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 Press2012.
2. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", Wiley2012.
3. Vehbi C. Güngör, DilanSahin, TaskinKocak, SalihErgüt, ConcettinaBuccella, Carlo Cecati, and Gerhard P. Hancke, "Smart Grid Technologies: Communication.

WEB RESOURCES:

1. https://www.smartgrid.gov
2. https://www.nist.gov/el/smart-grid
3. https://en.wikipedia.org/wiki/Smart_grid
4. https://www.smart-energy.com/industry-sectors/smart-grid/from-a-smart-grid-to-the-internet-of-energy

OUTCOMES:

Upon completion of the course, the student should be able to

1. Learners will develop more understanding on the concepts of Smart Grid and its present developments.
2. Learners will study about different Smart Grid technologies.
3. Learners will acquire knowledge about different smart meters and advanced metering infrastructure.
4. Learners will have knowledge on power quality management in Smart Grids
5. Learners will develop more understanding on LAN, WAN and Cloud Computing for Smart Grid applications

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	-	1	-	1	-	2	2	2	2	3	2
CO2	3	2	2	3	2	1	2	1	3	3	3	2	3	2
CO3	2	2	2	2	-	1	-	-	2	-	1	1	2	2
CO4	2	2	2	2	2	-	2	2	-	2	-	-	2	2
CO5	2	2	2	-	2	2	1	1	-	2	-	2	-	2

PROFESSIONAL ELECTIVES - II

		L	T	P	C
24PPEEL212 SDG NO. 4 & 7	SOLAR AND ENERGY STORAGE SYSTEMS	3	0	0	3

OBJECTIVES:

- 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

UNIT I INTRODUCTION **9**

Characteristics of sunlight - Semiconductors and P-N junctions - Behavior 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 - Standalone 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

TEXTBOOKS:

1. Solanki C.S., “Solar Photovoltaics: Fundamentals, Technologies And Applications”, PHI Learning Pvt. Ltd., 2005.
2. Stuart R. Wenham, Martin A. Green, Muriel E. Watt and Richard Corkish, “Applied Photovoltaics”, 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.

REFERENCES

1. McNeils, Frenkel, Desai, "Solar & Wind Energy Technologies", Wiley Eastern, 1990.
2. S. P. Sukhatme, "Solar Energy", Tata McGrawHill,1987.

WEB RESOURCES:

1. https://nptel.ac.in/content/storage2/courses/112105050/m1l1.pdf
2. https://www.seia.org/research-resources/major-solar-projects-list
3. https://en.wikipedia.org/wiki/Solar_energy
4. https://en.wikipedia.org/wiki/Solar_tracker

OUTCOMES:

Upon completion of the course, the student should be able to

1. Develop more understanding on solar energy storage systems.
2. Develop basic knowledge on standalone PV systems.
3. Understand the issues in grid connected PV systems.
4. Study about the modelling of different energy storage systems and their performances.
5. Able to attain more on different applications of solar energy.

CO-PO-PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	-	2	2	-	-	-	-	1	2	2
CO2	3	3	3	2	-	2	2	-	-	-	-	1	2	2
CO3	3	3	3	2	-	2	2	-	-	-	-	-	2	2
CO4	3	3	3	2	3	2	-	-	-	-	-	-	2	2
CO5	3	3	3	2	3	2	-	-	-	-	-	-	2	2

PROFESSIONAL ELECTIVES - III

24PPEEL213 SDG NO. 4 & 12	HIGH VOLTAGE DIRECT CURRENT TRANSMISSION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To impart knowledge on operation, modelling and control of HVDC links
- To perform steady state analysis of AC/DC systems
- To expose various HVDC simulators

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 principle 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 SYSTEM 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 Offline simulators - Dynamic interactions between DC and AC systems.

TOTAL : 45 PERIODS

TEXTBOOKS

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.

REFERENCES

1. J.Arrillaga, "High Voltage Direct Current Transmission", Peter Pregrinus, London, 1983.
2. Erich Uhlmann, "Power Transmission by Direct Current", BS Publications, 2004.
3. V.K. Sood, "HVDC and FACTS controllers - Applications of static converters in power system", APRIL 2004, Kluwer Academic Publishers.

WEB RESOURCES:

1. http://www.ewh.ieee.org/r6/san_francisco/pes/pes_pdf/HVDC_Technology.pdf
2. https://www.diva-portal.org/smash/get/diva2:730465/FULLTEXT01.pdf

COURSE OUTCOMES:

Upon completion of the course, the student should be able to

1. Ability to understand the principles, types and applications of HVDC systems.
2. Ability to analyze the concepts of HVDC converters and to acquire knowledge on DC link control.
3. Ability to understand the concepts of and protection of MTDC systems.
4. Ability to get knowledge about modelling of DC links and to understand the concepts of power flow analysis.
5. Ability to understand the importance of power flow in an HVDC system under steady state.

CO-PO-PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	2	2	1	1	-	-	-	2	2
CO2	3	3	2	2	2	1	1	-	-	-	2	2
CO3	3	3	3	2	2	1	1	-	-	-	2	2
CO4	3	3	3	2	2	1	1	-	-	-	2	2
CO5	2	3	3	2	2	1	1	-	-	-	2	2

PROFESSIONAL ELECTIVES - III

24PPEEL214 SDG NO. 4 &7	POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

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

UNIT I INTRODUCTION 9

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 photovoltaic 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

TEXT BOOKS:

1. S.N.Bhadra, D. Kastha, & S. Banerjee "Wind Electrical Systems", Oxford University Press,2009.
2. Rashid .M. H "Power Electronics Hand book", Academic press,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.

REFERENCES:

1. B.H.Khan, "Non-conventional Energy sources", Tata McGraw-hill Publishing Company.
2. P.S.Bimbhra,"Power Electronics",Khanna Publishers, 3rdEdition,2003.
3. Fang Lin Luo Hong Ye, " Renewable Energy systems", Taylor & FrancisGroup,2013.
4. R.Seyezhai and R.Ramaprabha, "Power Electronics for Renewable Energy Systems", Scitech Publications,2015.
5. Patranabis D, "Sensors and Transducers", 2nd Edition, PHI, New Delhi, 2010.

WEB RESOURCES:

1. https://www.energy.gov/eere/solar/power-electronics
2. https://en.wikipedia.org/wiki/Power_electronics
3. https://nptel.ac.in/courses/108/105/108105066/

OUTCOMES:

Upon completion of the course, the student should be able to

1. Analyze the impacts of renewable energy generation on the environment.
2. Understand the importance and qualitative analysis of solar and wind energy sources.
3. Apply the principle of operation of electrical machines for wind energy conversion and their performance characteristics.
4. Design suitable power converters for solar PV and wind energy systems.
5. Develop knowledge about hybrid renewable systems.

CO- PO,PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	3	3	2	1	2	-	-	-	-	-	3	2
CO2	3	3	2	1	1	2	2	-	-	1	-	3	3	3
CO3	3	3	2	2	1	1	1	1	-	-	2	3	3	3
CO4	3	3	3	2	1	3	2	-	-	1	1	3	2	3
CO5	3	3	1	-	2	1	2	-	2	-	3	2	3	3

PROFESSIONAL ELECTIVES - III

24PPEEL215 SDG NO. 4 & 9	ROBOTICS AND CONTROL	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To introduce robot terminologies and robotic sensors.
- To educate direct and inverse kinematic relations
- To educate on formulation of manipulator Jacobians and introduce path planning techniques
- To educate on robot dynamics
- To introduce robot control techniques

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-homogeneous 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

TEXT BOOKS:

1. R.K. Mittal and I J Nagrath, " Robotics and Control", Tata McGraw Hill, Fourth edition.
2. Saeed B. Niku ,''Introduction to Robotics '', Pearson Education,2002.
3. Fu, Gonzalez and Lee McGraw hill ,''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://www.robotics.org/Robotic-Resources
2. https://www.polytechforum.com/robotics/
3. https://it.toolbox.com/topics/innovation
4. https://nptel.ac.in/courses/112/101/112101099/

OUTCOMES:

Upon completion of the course, the student should be able to

1. Understand the components and basic terminology of Robotics
2. Model the motion of Robots
3. Analyze the workspace and trajectory planning of robots
4. Develop application based Robots
5. Formulate models for the control of mobile robots in various industrial applications.

CO- PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	3	2	-	-	1	-	-	-	-	1	2	3
CO2	3	3	3	1	2	1	-	-	-	-	-	1	3	3
CO3	3	3	2	2	1	1	1	-	-	-	-	1	3	3
CO4	2	2	3	1	1	-	-	-	1	-	-	1	3	2
CO5	3	3	3	2	2	1	1	-	1	-	1	1	3	2

PROFESSIONAL ELECTIVES - III

		L	T	P	C
24PPEEL216 **SDG NO. 4,7&9**	**WIND ENERGY CONVERSION SYSTEMS**	**3**	**0**	**0**	**3**

OBJECTIVES:

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

UNIT I INTRODUCTION **9**

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

UNIT II 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 variables 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 requirement - Low-voltage ride through (LVRT) - Ramp rate limitations - 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 modelling issue.

TOTAL: 45 PERIODS

TEXTBOOKS

1. L. L. Freris, “Wind Energy Conversion Systems”, Prentice Hall, 1990.
2. S. N. Bhadra, D. Kastha, S. Banerjee, “Wind Electrical Systems”, Oxford University Press, 2010.
3. Ion Boldea, “Variable Speed Generators”, Taylor & Francis group, 2006.

REFERENCES:

1. E. W. Golding “The Generation of Electricity by wind power”, Redwood burn Ltd., Trowbridge, 1976.
2. N. Jenkins, “Wind Energy Technology”, John Wiley & Sons, 1997.
3. S. Heir, “Grid Integration of WECS”, Wiley, 1998.

WEB RESOURCES:

1. https://openei.org/wiki/Wind_energy
2. https://www.awea.org/
3. https://www.nrel.gov/flatirons-campus/
4. https://nptel.ac.in/content/storage2/courses/108108078

OUTCOMES:

Upon completion of the course, the student should be able to

1. Acquire knowledge on the basic concepts of Wind Energy Conversion System.
2. Understand the mathematical modelling and control of the Wind Turbine.
3. Develop more understanding on the design of Fixed Speed System.

4. Develop more understanding on the design of the Variable Speed System.
5. Able to learn about Grid Integration issues and current practices of wind interconnections with power systems.

CO-PO PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	-	2	-	-	-	-	-	1
CO2	3	3	3	2	-	2	-	-	-	-	-	1
CO3	3	3	3	2	-	2	-	-	-	-	-	-
CO4	3	3	3	2	3	2	-	-	-	-	-	-
CO5	3	2	2	3	1	1	-	-	-	-	1	1

PROFESSIONAL ELECTIVES - III

24PPEEL217 SDG NO. 4 & 12	POWER QUALITY ASSESSMENT AND MITIGATION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To identify, analyze and create solutions for the power quality problems in power system networks

UNIT I INTRODUCTION 9

Importance of power quality - Terms and definitions as per IEEE std.1159 for transients, short and long duration voltage variations, interruptions, short and long voltage fluctuations, imbalance and flickers - Symptoms of poor power quality - Definitions and terminology of grounding - Purpose of groundings - Good grounding practices - problems due to poor grounding.

UNIT II- FLICKERS AND TRANSIENT VOLTAGES 9

RMS voltage variations in power system, complex power, voltage regulation and per unit system - Basic power flow and voltage drop - Devices for voltage regulation and impact of reactive power management - Causes and effects of voltage flicker - Short term and long term flickers - Methods to reduce flickers- Transient over voltages, impulsive transients, switching transients - Effect of surge impedance and line termination - Control of transient voltages.

UNIT III VOLTAGE INTERRUPTIONS 9

Definitions -Voltage sags versus interruptions - Economic impact, Major causes and consequences - Characteristics, assessment, Influence of fault location and fault level on voltage sag - Areas of vulnerability, Assessment of equipment sensitivity, Voltage sag limits for computer equipment-CBEMA, ITIC, SEMI F 42curves, Report of voltage sag analysis, Voltage sag indices, Mitigation measures for voltage sag- DSTATCOM, UPQC,UPS, DVR, SMEs, CVT, utility solutions and end user solutions.

UNIT IV WAVEFORM DISTORTION 9

Definition of harmonics, inter-harmonics, sub-harmonics - Causes and effects - Voltage versus current distortion, Fourier analysis, Harmonic indices, A.C. quantities under non-sinusoidal conditions, Triplet harmonics, characteristic and non characteristic harmonics- Series and Parallel resonances - Consequences- Principles for controlling and Reducing harmonic currents in loads, K-rated transformer - Computer tools for harmonic analysis - Locating sources of harmonics, Harmonic filtering - Passive and active filters - Modifying the system frequency response - IEEE Harmonic standard 519-1992.

UNIT V ANALYSIS AND CONVENTIONAL MITIGATION METHODS 9

Analysis of power outages, Analysis of unbalance condition - Symmetrical components in phasor quantities, Instantaneous symmetrical components, Instantaneous real and reactive powers - Analysis of distortion - On–line extraction of fundamental sequence components from measured samples – Harmonic indices – Analysis of voltage sag - Detroit Edison sag score, Voltage sag energy, Voltage Sag Lost Energy Index (VSLEI) - Analysis of voltage flicker, Reduced duration and customer impact of outages, Classical load balancing problem - Open loop balancing, Closed loop balancing, current balancing, Harmonic reduction, Voltage sag reduction.

TOTAL: 45 PERIODS

TEXT BOOKS

1. M. H. J. Bollen, "Understanding Power Quality Problems, Voltage Sag and Interruptions", IEEE Press, series on Power Engineering, 2000.
2. Roger C. Dugan, Mark F. McGranaghan, Surya Santoso and Wayne Beaty H., "Electrical Power System Quality", Second Edition, McGraw Hill Publication Co.,2008.
3. G.T.Heydt, "Electric Power Quality", Stars in a Circle Publications, 1994(2ndedition).

REFERENCE BOOK

1. Enrique Acha, Manuel Madrigal, "Power System Harmonics: Computer Modeling and Analysis", John Wiley and Sons,2001.

2. Arrillaga J. and Watson N, "Power System Harmonics"
3. IEEE Std. 519-1992/ IEEE Std. 1159 IEEE recommended practices and requirements for harmonics control in the electrical power system.

OUTCOMES:

Upon completion of the course, the student should be able to

1. Recognize the practical issues in the power system.
2. Analyze the impact of power electronic devices and techniques in power systems.
3. Develop troubleshooting skills and innovative remedies for various power quality problems in the power system.
4. Understand the concept of harmonics in different systems.
5. Study the concept of mitigation methods of power quality methods

CO- PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	3	3	2	1	2	-	-	-	-	-	3	2
CO2	3	3	2	1	1	2	2	-	-	1	-	3	3	3
CO3	3	3	2	2	1	1	1	1	-	-	2	3	3	3
CO4	3	3	3	2	1	3	2	-	-	1	1	3	2	3
CO5	3	3	1	-	2	1	2	-	2	-	3	2	3	3

PROFESSIONAL ELECTIVES - III

		L	T	P	C
24PPEEL218 **SDG NO. 4**	**NON-LINEAR DYNAMICS FOR POWER ELECTRONICS CIRCUIT**	**3**	**0**	**0**	**3**

OBJECTIVES:

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

UNIT I BASICS OF NONLINEAR DYNAMICS 9

Basics of Nonlinear Dynamics: System - state and state space model- Vector field- Modeling of Linear-nonlinear and Linearized systems – Attractors- chaos- Poincare map- Dynamics of Discrete time system- Lyapunov Exponent –Bifurcations- Bifurcations of smooth map- Bifurcations in piecewise smooth maps- border crossing and border collision bifurcation.

UNIT II TECHNIQUES FOR INVESTIGATION OF NON LINEAR 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

TEXT BOOKS:

1. George C. Vargheese, July 2001 Wiley – IEEE Press S Banerjee, Nonlinear Phenomena in Power Electronics, IEEE Press3.
2. Steven H Strogatz, Nonlinear Dynamics and Chaos, WestviewPress
3. C.K.TSE Complex Behaviour of Switching Power Converters, CRC Press,2003.

WEB RESOURCES:

1. https://resources.pcb.cadence.com/blog/2019-the-basics-of-linear-vs-nonlinear-circuits
2. https://info.ornl.gov/sites/publications/Files/Pub57485.pdf

OUTCOMES:

Upon completion of the course, the student should be able to

1. Determine the non-linear phenomena
2. Understand the techniques for investigating non-linear phenomena
3. Analyze the behaviour of non-linearity in DC-DC Converters
4. Analyze the phenomena of non-linearity in drives
5. Design a power electronics control circuit

CO- PO,PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	2	-	-	-	-	1	1	-	2	1
CO2	2	2	1	2	2	-	-	-	-	1	1	-	2	2
CO3	2	2	1	2	2	-	-	-	-	1	1	1	2	1
CO4	2	2	1	2	2	-	-	-	-	1	1	1	2	1
CO5	2	2	1	2	2	-	-	-	-	1	1	-	2	1

PROFESSIONAL ELECTIVES - IV

24PPEEL301 SDG NO. 4 &9	POWER ELECTRONIC APPLICATION TO POWER SYSTEM	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To expose the students to the applications of power electronics based circuits to improve the performance of power systems

UNIT I THREE PHASE CONVERTERS IN HVDC 9

Three phase Converters (line commutated and PWM) - Introduction to HVDC - Effect of source and load inductance - Harmonics in power system due to power converters – Standards - Advanced converter topologies (Matrix and Multilevel).

UNIT II WIND AND SOLAR PV ENERGY CONVERSION SYSTEMS 9

Basic components of wind energy conversion system – Generators – Types - Solar PV energy conversion system - DC and AC power conditioners for solar PV.

UNIT III CONVERTER CONTROL **9**

Control characteristics of inverter and rectifier in HVDC – Over view of control techniques for grid connected converters - Control of active and reactive power.

UNIT IV POWER QUALITY AND FAULT ANALYSIS **9**

Impact of power electronics in power system – Harmonics - Flicker – Remedies-Fault behavior of wind and solar systems - International standards for grid integration of Renewable Energy Sources.

UNIT V MODELING AND POWER FLOW ANALYSIS **9**

Modeling - Converters – Filters - Load flow analysis - Power system with power converter based Renewable Energy - FACTS Controllers - Protection of power converters.

TOTAL : 45 PERIODS

TEXT BOOKS

1. Rakesh Das Bagamudre, “Extra High Voltage ACtransmission Engineering”, NewAge International Ltd., Third Edition, 2007.
2. R.SastryVedam, S.Sarma, “ Power Quality VAR compensation in Power systems”, CRCPress,2009.
3. Padiyar.K.R.,“HVDC Power Transmission System”, Wiley Eastern Limited, New Delhi,2011.

REFERENCE BOOK

1. Remus Teodorescu, Marco Liserre, Pedro Rodriguez “Grid Converters for Photovoltaic and Wind Power Systems” JohnWiley and SonsLtd.,2011
2. Mukund R Patel, “Wind and Solar power systems: design, analysis and operation”, SecondEdition,Taylor& Francis, 2006.

COURSE OUTCOMES:

Upon completion of the course, the student should be able to

1. Identify high power devices and associated control techniques for improving performance of power system.
2. Analyze the power system with power electronics based controllers.
3. Apply relevant power electronic circuits for wind and solar energy conversion systems
4. Learners will have knowledge on power quality and fault analysis in the power system
5. Ability to formulate models and analysis for the various controllers

CO- PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	2	1	-	-	-	-	1	1	3	3
CO2	3	3	2	2	2	1	-	-	-	-	1	1	3	3
CO3	3	3	2	2	2	1	-	-	-	-	1	1	3	3
CO4	3	3	2	2	2	1	-	-	-	-	1	1	3	3
CO5	3	3	3	2	2	1	-	-	-	-	1	1	3	3

PROFESSIONAL ELECTIVES - IV

24PPEEL302 SDG NO. 4	DIGITAL CONTROL FOR POWER ELECTRONIC APPLICATIONS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To provide the requisite knowledge to appreciate the digital Control system in Power Electronics and its design and implementation.

UNIT I DIGITAL CONTROL SYSTEMS 9

Concepts of digital control -Structure of digital control system -Discrete time systems: Sampling and reconstruction of signals - ZOH circuits - Introduction to z-transforms and inverse z-transforms – Modeling of digital control systems.

UNIT II STABILITY OF DIGITAL CONTROL SYSTEMS AND DESIGN 9

Stability conditions - Stability determination - Nyquist criterion - Phase margin and gain margin, Z-domain root locus - Z-domain P, PI, PID control design - Frequency response design – State space modeling of power converters.

UNIT III DIGITAL CONTROL APPLICATION IN POWER ELECTRONIC CIRCUITS 9

Single phase inverter - Digital current mode control - Requirements of digital controller - Basic current control implementations: PI - Predictive controller Three Phase Systems: Space vector modulation - Rotating reference frame current controller - Design of rotating reference frame PI current controller.

UNIT IV EXTERNAL CONTROL LOOPS **9**

Modeling of internal control loops - Design of voltage controllers - Large band width controllers – Narrow band width controllers - Applications of current controllers.

UNIT V DESIGN OF FPGA AND DSP BASED SYSTEMS **9**

Introduction to Field Programmable Gate Arrays-types of FPGA-DSP Slices-Design example-Introduction to DSP - Modeling of DSP algorithms in MATLAB - conversion of MATLAB models into fixed point VHDL blocks - Platform implementation issues: FPGA vs DSP

TOTAL: 45 PERIODS

REFERENCE BOOKS:

1. Simone Buso, paoloMattavelli, "Digital control in power electronics", Morgan & Claypool Publishers, 2006
2. M.Sami Fadali , "Digital control engineering analysis and design" Academic Press,2012.
3. Ogata:K, "Modern Control Engineering"—Prentice Hall–2014
4. B K Bose , "Modern Power Electronics and AC Drives" —Pearson Publication 1st Edition,2011.
5. Prof Miguel Castilla (ed.), "Control Circuits in Power Electronics: Practical issues in design and implementation" IET,2016.

OUTCOMES:

Upon completion of the course, the student should be able to

1. Understand the concept of digital control systems and be able to design and deal with the Z- domain representation of systems.
2. Test the real time system stability and design of control loops in digital domain
3. Analyze the system dynamics with digital controllers.
4. Enrich knowledge for research studies in digital controller based power electronic systems.
5. Perform design of FPGA and DSP based system

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	1	-	1	2	-	-	-	3	2	3
CO2	3	3	3	2	-	2	1	-	2	2	1	3	2	3
CO3	3	3	2	2	-	-	1	3	-	-	-	2	1	3
CO4	3	3	2	2	1	2	-	-	1	1	3	3	2	3
CO5	3	3	2	2		2	1	-	1	2	2	2	2	3

PROFESSIONAL ELECTIVES - IV

24PPEEL303 SDG NO. 4	SIMULATION OF POWER ELECTRONIC SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To provide the requisite knowledge to appreciate the dynamical equations involved in the analysis of different converter, inverter and controller configurations.

UNIT I INTRODUCTION 9

Need for simulation-challenges in simulation-classification of simulation programs –overview of PSPICE, MATLAB and SIMULINK. Mathematical modeling of Power Electronic Systems-Static and dynamic models of power electronic switches-Static and dynamic equations- State space representation of power electronic systems.

UNIT II PSPICE 9

File formats-Description of circuit elements-Circuit description- Output variables-Dot commands – SPICE models of Diode, Thyristors, TRIAC, BJT, Power MOSFET, IGBT and Power S-functions – Converting Rating basic statistics. Converting S-Functions to blocks.

UNIT III MATLAB and SIMULINK 9

MATLAB-Intro Variables – Matrix representation and operation, Trigonometric functions, Logical relations, Exponential Complex Numbers, -m file-function – for loop – while – if else, Graphics- 2D plots, SIMULINK: Basic

Block-Sources and Sinks model analysis using SIMULINK – S-functions – converting S-functions to blocks.

UNIT IV INTRODUCTION TO PSIM 9

General information – power circuit components – control circuit – other components – Analysis specification-circuit schematic design-waveform processing-Error and warning messages.

UNIT V SIMULATION USING PSPICE, PSIM, MATLAB AND SIMULINK 9

Diode rectifiers-controlled rectifiers-AC voltage controllers-DC choppers-PWM inverters – Voltage source – Current source inverters-Resonant pulse inverters-Zero current switching and zero voltage switching inverters.

TOTAL : 45 PERIODS

REFERENCE BOOK:

1. Rashid,M.H., " SPICE for power electronics and Electric Power", CRC Press, 3rd Edition. 2012.
2. Ned Mohan," Power Electronics, Computer simulation Analysis and Education using PSPICE", Minnesota Power Electronics Research and Education, USA, 1999.
3. Chee-Mun-Ong," Dynamic simulation of Electric Machinery using MATLAB/SIMULINK", Prentice hall Pvt Ltd, New Jersey, 1998.
4. "The PSPICE user's Guide:, Microsim Corporation, California, 1996.
5. "The SIMULINK User's Guide", Math works Inc, 2006
6. " PSIM User's Guide", Powersim Inc., 2006

OUTCOMES

Upon completion of the course, the student should be able to

1. Analyze and design different power converters studied in the core course on power converters..
2. Apply and analyze the functions of different power electronics switches through simulation.
3. Design of different control circuits for different power converters.
4. Able to understand of PSPICE software with examples
5. Simulation of converters with different software.

CO- PO, PSO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	3	-	-	-	-	-	-	-	1	1
CO2	3	3	3	3	2	-	-	-	-	-	-	-	1	1
CO3	3	3	3	2	3	-	-	-	-	-	-	-	1	1
CO4	3	3	3	3	2	-	-	-	-	-	-	-	2	1
CO5	3	3	3	2	3	-	-	-	-	-	-	-	2	2

PROFESSIONAL ELECTIVES - IV

		L	T	P	C
24PPEEL304 **SDG NO. 4**	**COMPUTER AIDED DESIGN OF ELECTRICAL MACHINES**	**3**	**0**	**0**	**3**

OBJECTIVES:

- To design and model the field oriented concepts of electrical machines using FEM and modern Engineering tools

UNIT I DESIGN PROCEDURE **9**

Conventional design procedures-Limitations-Main dimensions and Field system of DC and AC machines- problems.

UNIT II MATHEMATICAL FORMULATIONS OF FIELD PROBLEMS **9**

Development of torque/force – Electromagnetic Field Equations – Magnetic Vector/ Scalar potential - Electrical Vector/ Scalar potential – Stored energy in field problems – Inductance – Laplace and Poisson’s equations –Maxwell equations – Problems.

UNIT III PHILOSOPHY OF FEM **9**

Differential / Integral equations – Numerical methods - Finite Difference method – Finite Element method – Moment method - Energy minimization – Variational method – 2D field problems –Discrimination – Shape functions – Stiffness matrix .

UNIT IV CAD PACKAGES **9**

Energy functional – Principle of energy conversion - Elements of a CAD System – Preprocessing – Modeling –Simple iterative methods - Newton Raphson and

Gauss Seidal Methods - Meshing – Materials properties - Boundary Conditions – Solution techniques – Post processing and Optimization.

UNIT V APPLICATIONS 9

Design of Solenoid Actuator – Switched reluctance motor - Induction motor - Stepper motor.

TOTAL: 45 PERIODS

REFERENCE BOOKS:

1. Silvester and Ferrari, "Finite Elements for Electrical Engineers", Cambridge University Press, New York,Third Edition,1996.
2. Trowbridge C.W, "An Introduction to Computer Aided Electromagnetic Analysis", Vector Fields Ltd., Oxford,1990.
3. Hoole S.R.H, "Computer Aided Analysis and Design of Electromagnetic Devices", Elsevier Science Publishing Co., New York,1989.
4. Sawhney A.K, "A Course in Electrical Machine Design", DhanpatRai& Sons, New Delhi,1996.
5. Sawhney A.K, Chakrabarti. A, "A Course in Electrical Machine Design", DhanpatRai, Sixth Edition, 2010.

OUTCOMES

Upon completion of the course, the student should be able to

1. Apply the knowledge of machine design and model the system using field concepts.
2. Analyse the designed system using CAD packages.
3. Evaluate the performance of each machine using various modern engineering tools.
4. Formulate and solve the optimum design problems with computers.
5. Design the various CAD models for different applications.

CO- PO,PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	-	-	-	-	-	-	-	3	2	2
CO2	2	2	2	2	3	-	1	-	2	1	-	-	2	2
CO3	2	2	3	2	2	-	1	-	-	-	2	-	3	2
CO4	2	2	1	3	1	-	-	-	-	2	-	2	2	2
CO5	1	2	2	3	1	-	1	-	-	-	-	1	2	2

PROFESSIONAL ELECTIVES - IV

24PPEEL305 SDG NO. 4 & 9	SWITCHED MODE POWER CONVERTERS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To comprehend the design and analysis of advanced power converter topologies for real time applications.

UNIT I INTRODUCTION 9

Switching devices - Ideal and real characteristics, control - Drive and protection -Design of inductor, Design of transformer - Capacitors for power electronic applications.

UNIT II DC-TO-DC CONVERTERS 9

Basic concepts of Switched Mode power converters - Primitive DC to DC Power Converter-Operating Principle - Exact and Approximate Analysis.

UNIT III TOPOLOGIES 9

Non-isolated DC to DC Power Converter- Buck, Boost, Buck-Boost, Cuk , SEPIC and Quadratic Converters - Isolated DC to DC Power Converter - Forward, Fly back, Half/Full Bridge Converters. - Steady - State model, dynamic model, analysis, modeling and performance functions of switching power converters.

UNIT IV RESONANT CONVERTERS 9

Classification of resonant converters - Basic resonant circuit concepts, Load resonant converters - Resonant switch converters - Zero voltage and current switching.

UNIT V CLOSED LOOP CONTROL OF POWER CONVERTERS 9

Closed Loop Control of Switching Converters- Steady State Error, Control Bandwidth, and Compensator Design- Closed Loop Dynamic Performance Functions- Design of feedback compensators - Unity power factor rectifiers - Resistor emulation principle - Applications to rectifiers.

TOTAL : 45 PERIODS

REFERENCE BOOK :

1. Robert W. Erickson, DraganMaksimovic"Fundamentals of Power Electronics," Springer,2005.
2. Ramanarayanan V., "Course Material on Switched Mode Power Conversion", Department of Electrical Engineering, Indian Institute of Science, Bangalore, 2007.

3. Issa Batarseh, 'Power Electronic Circuits', John Wiley, 2004.
4. Philip T Krei, ' Elements of Power Electronics `, Oxford Press, 2nd edition 2015.
5. L.Umanand, "Power Electronics Essentials & Applications", Wiley India Pvt. Ltd., 2009

WEB RESOURCES:

1. https://nptel.ac.in/courses/108108036/
2. https://www.sciencedirect.com/book/9780120887958/switch-mode-power-converters
3. https://freevideolectures.com/course/3208/switched-mode-power-conversion

OUTCOMES:

Upon completion of this course, the student should be able to

1. Design new and efficient power converters suitable for specific applications
2. Develop control techniques for power converters.
3. Analyse the existing topologies
4. Explain resonant converters
5. Analyze closed loop converters.

CO- PO,PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	3	2	-	-	1	-	-	-	-	1	2	3
CO2	3	3	3	1	2	1	-	-	-	-	-	1	3	3
CO3	3	3	2	2	1	1	1	-	-	-	-	1	3	3
CO4	2	2	3	1	1	-	-	-	1	-	-	1	3	2
CO5	3	3	3	2	2	1	1	-	1	-	1	1	3	2

PROFESSIONAL ELECTIVES - IV

24PPEEL306 SDG NO. 4 & 12	ENERGY MANAGEMENT AND AUDITING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To study the concepts behind economic analysis and Load Management
- To emphasize energy management on various electrical equipment and metering
- To illustrate the concept of lightning systems and cogeneration

UNIT I INTRODUCTION **9**

Need for energy management - Energy basics - Designing and starting an energy management program - Energy accounting - Energy monitoring, Targeting and Reporting - Energy audit process.

UNIT II ENERGY COST AND LOAD MANAGEMENT **9**

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

UNIT III ENERGY MANAGEMENT FOR MOTORS, SYSTEMS, AND ELECTRICAL EQUIPMENT **9**

Systems and equipment - Electric motors - Transformers and reactors - Capacitors and synchronous machines.

UNIT IV METERING FOR ENERGY MANAGEMENT **9**

Relationship between parameters - Units of measure - Typical cost factors - Utility meters - Timing of meter disc for kilowatt measurement - Demand meters - Paralleling of current transformers - Instrument transformer burdens - Multitasking solid-state meters - Metering location vs. requirements - Metering techniques and practical examples.

UNIT V LIGHTNING SYSTEMS & COGENERATION **9**

Concept of lightning systems - The task and the working space - Light source - Ballasts - Luminaries - Lightning controls - Optimizing lightning energy - Power factor and effect of harmonics on power quality - Cost analysis techniques - Lightning and energy standards Cogeneration: Forms of cogeneration - Feasibility of cogeneration - Electrical interconnection.

TOTAL: 45 PERIODS

TEXTBOOKS:

1. Barney L. Capehart, Wayne C. Turner, and William J.Kennedy, "Guide to Energy Management", Fifth Edition, The Fairmont Press, Inc., 2006.
2. Eastop T.D & Croft D.R, "Energy Efficient for Engineers and Technologists", Longman Scientific & Technical, 1990.

REFERENCES:

1. Reay D.A, "Industrial Energy Conservation", 1st Edition, Pergamon Press, 1977.
2. "IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities", IEEE, 1996.
3. Amit K. Tyagi, "Handbook on Energy Audits and Management", TERI, 2003.

WEB RESOURCES:

1. https://beeindia.gov.in/sites/default/files/1Ch3.pdf
2. https://www.seai.ie/publications/SEAI-Energy-Audit-Handbook.pdf
3. https://en.wikipedia.org/wiki/Energy_audit
4. https://www.energy.gov/energysaver/home-energy-audits/do-it-yourself-home-energy-audits

OUTCOMES:

Upon completion of this course, the student should be able to

1. Students will develop the ability to learn about the need for energy management and auditing processes.
2. Learners will learn about basic concepts of economic analysis and load management.
3. Students will understand the energy management of various electrical equipment.
4. Students will have knowledge on the concepts of metering and factors influencing cost function.
5. Students will be able to learn about the concept of lightning systems, Light sources and various forms of cogeneration.

CO-PO-PSO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	3	2	-	-	1	-	-	-	2	1	2	3
CO2	3	3	3	1	-	1	-	-	-	-	1	1	3	2
CO3	3	3	2	2	-	1	1	-	-	-	2	1	2	2
CO4	2	2	2	1	1	-	-	-	-	-	-	1	3	2
CO5	3	3	3	2	1	1	1	-	1	-	-	1	3	2

PROFESSIONAL ELECTIVES - V

24PPEEL307 SDG NO. 4 & 11	ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To provide fundamental knowledge on electromagnetic interference and electromagnetic compatibility.
- To study the important techniques to control EMI and EMC.
- To expose the knowledge on testing techniques as per Indian and international standards in EMI measurement
- To Understand the concepts of measurement technology

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 modeling, 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 intermodulation, 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 equipment- 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

TEXT BOOKS:

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.

REFERENCES:

1. Bridges, J.E Milleta J. and Ricketts.L.W., "EMP Radiation and Protective techniques", John Wiley and sons, USA1976
2. William Duff G., & Donald White R. J, "Series on Electromagnetic Interference and Compatibility", Vol.
3. Weston David A., "Electromagnetic Compatibility, Principles and Applications",1991.

WEB REFERENCES:

1. https://interferencetechnology.com/electromagnetic-interference-sources-and-their-most-significant-effects/
2. https://en.m.wikipedia.org/wiki/Electromagnetic_interference

3. https://www.herzan.com/resources/applications/noise-source/electromagnetic-interference.html

OUTCOMES:

Upon completion of the course, the student should be able to

1. Understand EMC regulation and methods of eliminating interferences
2. Explain about the Methods of grounding of cable shield
3. Understand the concept of filtering and shielding
4. Explain about the types of digital circuit noises
5. Learning about electrostatic discharge and standards

CO- PO,PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	-	1	1	-	-	-	1	-	-	-	2	2
CO2	1	2	1	2	1	-	-	-	1	-	1	-	2	2
CO3	3	3	1	1	2	-	-	-	-	3	1	-	2	2
CO4	3	1	2	1	1	-	-	-	-	-	-	-	2	1
CO5	3	3	1	3	1	-	-	-	3	-	-	-	1	1

PROFESSIONAL ELECTIVES - V

24PPEEL308 SDG NO. 4,8&12	MODERN AUTOMOTIVE SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To expose the students with theory and applications of Automotive Electrical and Electronic Systems

UNIT I INTRODUCTION TO MODERN AUTOMOTIVE ELECTRONICS 9

Introduction to modern automotive systems and need for electronics in automobiles - Role of electronics and microcontrollers - Sensors and actuators - Possibilities and challenges in automotive industry - Enabling technologies and industry trends.

UNIT II SENSORS AND ACTUATORS 9

Introduction - Basic sensor arrangement - Types of sensors - Oxygen sensor, engine crank shaft angular position sensor – Engine cooling water temperature sensor - Engine oil pressure sensor - Fuel metering - Vehicle speed sensor and detonation sensor - Pressure Sensor - Linear and angle sensors - Flow sensor - Temperature and humidity sensors - Gas sensor - Speed and Acceleration sensors - Knock sensor - Torque sensor - Yaw rate sensor - Tyre Pressure sensor - Actuators - Stepper motors – Relays.

UNIT III POWER TRAIN CONTROL SYSTEMS IN AUTOMOBILE 9

Electronic Transmission Control - Digital engine control system: Open loop and closed loop control systems- Engine cooling and warm up control – Acceleration - Detonation and idle speed control - Exhaust emission control engineering - On board diagnostics - Future automotive powertrain systems.

UNIT IV SAFETY, COMFORT AND CONVENIENCE SYSTEMS 9

Cruise Control - Anti-lock Braking Control - Traction and Stability control - Airbag control system - Suspension control - Steering control - HVAC Control.

UNIT V ELECTRONIC CONTROL UNITS (ECU) 9

Need for ECUs - Advances in ECUs for automotives - Design complexities of ECUs - V-Model for Automotive ECU„s - Architecture of an advanced microcontroller (XC166 Family, 32-bit Tricore) used in the design of automobile ECUs- On chip peripherals, protocol interfaces, analog and digital interfaces.

TOTAL: 45 PERIODS

TEXTBOOKS

1. Ronald K. Jurgen, "Automotive Electronics Handbook" , McGraw Hill, 2000.
2. LjuboVlacic, Michel Parent and FurnioHarshima, "Intelligent Vehicle Technologies: Theory and Applications", Butterworth Heinemann publications, 2001.
3. Denton, "Automotive Electrical and Electronic Systems", Burlington, MA 01803, Elsevier Butterworth-Heinemann, 2004.

REFERENCE BOOK

1. Jack Erjavec,"Automotive Technology – A System Approach", Thomson Delmar Learning, 3rdedition,2004.
2. XC166 Family and 32-bit Tricore Family of microcontrollers.

WEB RESOURCES:

1. https://www.udemy.com/course/sensors-sensor-fundamentals/
2.. https://books.google.co.in/books?id=AgbFyQeH3jsC&printsec=

frontcover&dq=automotive+systems&hl=en&sa=X&ved=0ahUKEwiZvtWZi_noAhUEzDgGHaTRDdYQ6AEIJzAA#v=onepage&q=automotive%20systems&f=false
3. https://www.scribd.com/document/406099814/vol-i-pdf

ONLINE RESOURCES:

1. https://nptel.ac.in/courses/107/106/107106088/
2. https://www.udemy.com/course/overview-of-automotive-performance-engineering/
3. https://nptel.ac.in/courses/108/108/108108147/

OUTCOMES:

Upon completion of the course, the student should be able to

1. Familiar with various automotive electronics systems.
2. Explain about control strategies of automotive systems.
3. Apply modern techniques to automobiles.
4. Understand the safety and control systems in Automotive systems
5. Application of digital and microcontrollers in automotive systems.

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	-	1	-	1	-	-	-	-	2	2	2	2
CO2	2	2	2	1	-	1	-	-	-	-	2	2	2	2
CO3	2	2	2	1	-	1	-	-	-	-	2	2	2	2
CO4	2	2	1	1	-	1	-	-	-	-	2	2	2	2
CO5	2	2	2	1	2	1	-	-	-	-	2	2	2	2

PROFESSIONAL ELECTIVES - V

24PPEEL309 SDG NO. 4&7	ADVANCED ENERGY STORAGE TECHNOLOGY	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To recollect the historical perspective and technical methods of energy storage
- To outline the technical methods of storage

- To determine the performance factors of energy storage systems
- To discuss the hybrid energy storage and hydrogen fuel cell
- To identify applications for renewable energy systems

UNIT I STORAGE: INTRODUCTION AND CHANGES 9

Storage Needs - Variations in Energy Demand - Variations in Energy Supply - Interruptions in Energy Supply - Transmission Congestion - Demand for Portable Energy - Demand and scale requirements - Environmental and sustainability issues.

UNIT II TECHNICAL METHODS OF STORAGE 9

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

UNIT III PERFORMANCE FACTORS OF ENERGY STORAGE SYSTEMS 9

Energy capture rate and efficiency - Discharge rate and efficiency - Dispatch ability and load flow characteristics, scale flexibility, durability – Cycle lifetime, mass and safety – Risks of fire, explosion, toxicity - Ease of materials, recycling and recovery - Environmental consideration and recycling, Merits and demerits of different types of Storage.

UNIT IV HYDROGEN FUEL CELLS AND FLOW BATTERIES 9

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

UNIT V APPLICATION OF ENERGY STORAGES 9

Battery Storage System: Introduction with focus on Lead Acid and Lithium - Chemistry of Battery Operation, Power storage calculations, Reversible reactions, Charging patterns, Battery Management systems, System Performance, Areas of Application of Energy Storage: Waste heat recovery, Solar energy storage, Greenhouse heating, Power plant applications, Drying and heating for process industries, energy storage in automotive applications in hybrid and electric vehicles.

TOTAL: 45 PERIODS

TEXT BOOK:

1. Jiujun Zhang, Lei Zhang, Hansan Liu, Andy Sun, Ru-Shi Liu, "Electrochemical Technologies for Energy Storage and Conversion", John Wiley and Sons,2012.
2. Doughty Liaw, Narayan and Srinivasan, "Batteries for Renewable Energy Storage", The Electrochemical Society, New Jersey,2010.

REFERENCE BOOK:

1. Detlef Stolten,"Hydrogen and Fuel Cells: Fundamentals, Technologies and Applications", Wiley, 2010.
2. Francois Beguin and ElzbietaFrackowiak ,"Super capacitors", Wiley,2013.
3. Michael Sterner ,Ingo Stadler "Handbook of Energy Storage- Demand, Technologies, Integration" by Springer-Verlag Berlin Heidelberg 2019(eBook ISBN978-3-662-55504-0)

WEB RESOURCES :

1. www.enegrystorage.org/technologies
2. https://www.eesi.org/papers/view/energy-storage-2019
3. https://www.geni.org/globalenergy/research/energy-storage-technologies/Energy-Storage-Technologies.pdf
4. https://www.renewableenergyworld.com/
5. https://www.forbes.com/

OUTCOMES:

Upon completion of the course, the student should be able to

1. Explore the historical changes and provide solution for environmental and sustainability issues.
2. Understand the different types of energy and various method of energy storage.
3. Outline the different performance factors devices according to environmental constraints.
4. Able to design the hybrid fuel cell and flow batteries according to application
5. Able to categorize the energy storage devices to different application

CO- PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	3	1	1	-	3	-	-	2	1	2	3	3
CO2	2	1	3	1	1	-	2	-	-	2	2	2	2	2
CO3	2	2	3	2	1	-	3	-	-	2	1	2	2	3
CO4	2	1	3	1	1	-	2	-	-	2	2	2	3	3
CO5	1	1	3	1	1	-	3	-	-	2	1	2	3	3

PROFESSIONAL ELECTIVES - V

24PPEEL310 SDG NO. 4&9	ADVANCED ELECTRIC DRIVES AND CONTROL	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To study and analyze the performance of electric drives with modern controllers and techniques

UNIT I INTRODUCTION **9**

Need for advanced controls - Principle factor affecting the choice of drive – Parameter identification techniques for electric motors – Electromagnetic compatibility of electric drives – Different options for an adjustable speed electric drive – Simulation of electrical drives – Advanced control strategies for electrical drives – DSP based control of electric drives.

UNIT II DSP CONTROLLERS AND INSTRUCTION SET **9**

TMS 320 family overview – 320 C24X Series of DSP controllers – Architecture – C24X CPU internal bus structure – Central processing unit – Memory and I/O spaces – Program control – Address modes – System configuration and interrupts – Clocks and low power modes – Digital input/output. Instruction set: Assembly language instructions – Instruction set and description – Accumulator, arithmetic and logic instructions – Auxiliary register and data page pointer instructions – TREG, PREG, Multiply instructions – Branch instructions – Control instructions – I/O and memory instructions.

UNIT III PWM INVERTER CONTROL **9**

Inverter – Operation principle – Inverter switching – Unipolar – Bipolar – Inverter deadtime – Inverter modulation – Different types – Sine Triangle –

Analysis of Sine Triangle Modulation – Trapezoidal Modulation – Third harmonic Modulation – Analysis of Third Harmonic Modulation – Output filter requirement for different PWM techniques.

UNIT IV SPACE VECTOR MODULATION 9

Concept of a Space Vector – dqo Components for Three-phase sine wave source – dqo Components for Voltage Source Inverter operated in Square Wave Mode – Synchronously rotating reference frame – Space Vector Modulation – Principle – SVM compared to regular sampled PWM phase lag reference for SVM – Naturally sampled SVM – Analytical solution – Harmonic losses – Placement of Zero Space Vector – Discontinuous Modulation – Phase lag reference for discontinuous PWM.

UNIT V ADVANCED CONTROLLERS 9

Current and speed control of Induction Motor – Current control algorithm – Sensorless motion control strategy – Induction Motor Controller using VHDL design. Fuzzy Logic Control of a Synchronous Generator – System representation – VHDL Modeling –FPGA implementation.

TOTAL : 45 PERIODS

TEXT BOOKS

1. Bimal K. Bose, "Power Electronics and Variable Frequency Drives – Technology and Applications", IEEE Press, 1997.
2. Grafame Holmes. D and Thomas A. Lipo, "Pulse Width Modulation for Power Converters–Principles and Practice", IEEE Press, 2003.
3. Peter Vas, "Vector Control of AC Machines", Oxford University Press, 1990.
4. Hamid A. Toliyat and Steven G.Campbell, "DSP based Electromechanical Motion Control",CRC Press 2004.
5. Ned Mohan, "Advanced Electric Drives: Analysis, Control and ModellingusingSIMULINK",John Wiley & Sons Ltd., 2014. .

REFERENCE BOOK

1. Theodore Wildi, "Electrical Machines, Drives, and Power Systems", Pearson Education., (5th Edition), 2002.
2. Pillai.S.K "A First Course on Electric Drives", Wiley Eastern Limited, 2012
3. Vedam Subrahmanyam, "Electric Drives (Concepts and Applications)", Tata McGraw-Hill, 2010

WEB RESOURCES:

1. https://www.springer.com/gp/book/9789400701793

2. https://www.researchgate.net/publication/260946860_Advanced_Electrical_Drives_Analysis_Modeling_Control_Book_News
3. https://nptel.ac.in/courses/108104011/
4. http://www.iitmandi.ac.in/academics/senate_courses

OUTCOMES:

Upon completion of the course, the student should be able to

1. Understand about the various electrical drives
2. Understand the DSP controllers for electrical drives
3. Understand the PWM inverter control for electrical drives
4. Analyze the impact of space vector modulation for controlling the electrical drives
5. Acquire the knowledge of advanced controllers

CO- PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	1	1	1	-	-	-	-	-	-	2	2
CO2	3	3	3	1	3	1	-	-	-	-	1	1	3	3
CO3	3	3	3	1	3	1	-	-	-	-	1	1	3	3
CO4	3	3	3	1	3	1	-	-	-	-	1	1	3	3
CO5	3	3	3	1	3	1	-	-	-	-	1	1	3	3

PROFESSIONAL ELECTIVES - V

24PPEEL311 SDG NO. 4&9	ADVANCED CONTROL SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To provide knowledge on design state feedback control and state observer
- To provide knowledge in phase plane analysis
- To give basic knowledge in describing function analysis
- To study the design of optimal controllers
- To study the design of optimal estimators including Kalman Filter

UNIT I STATE VARIABLE ANALYSIS 9

Introduction - Concepts of state variables and state model for linear continuous time systems, Diagonalization - Solution of state equations - Concepts of controllability and observability.

UNIT II STATE VARIABLE DESIGN 9

Introduction to state model : Effect of state feedback - pole placement design : Necessary and sufficient condition for arbitrary pole placement, State regulator design of state observers - Separation principle - Design of servo systems : State feedback with integral control.

UNIT III SAMPLED VARIABLE DESIGN 9

Introduction spectrum analysis of sampling process signal reconstruction difference equations - The Z transform function, the inverse Z transform function, response of Linear discrete system - The Z transform analysis of sampled data control systems, response between sampling instants, The Z and S domain relationship. Stability analysis and compensation techniques.

UNIT IV NONLINEAR SYSTEMS 9

Introduction - Common physical nonlinearities - The phase plane method: concepts, singular points, stability of nonlinear systems, construction of phase trajectories system analysis by phase plane method. The describing function method, stability analysis by describing function method, Jump resources.

UNIT V OPTIMAL CONTROL 9

Introduction: Classical control and optimization, formulation of optimal control problem, Typical optimal control performance measures - optimal state regulator design: Lyapunov equation, Matrix Riccati equation - LQR steady state optimal control - Application examples.

TOTAL : 45 PERIODS

TEXT BOOKS:

1. M. Gopal, "Digital Control and State Variable Methods", 4th edition, McGraw Hill India, 2012.
2. K. Ogata, "Modern Control Engineering", 5th edition, Pearson, 2012.
3. K. P. Mohandas, "Modern Control Engineering", Sanguine Technical Publishers, 2006.

REFERENCES:

1. M. Gopal, Modern Control System Theory, 3rd edition, New Age International Publishers, 2014.
2. William S Levine, "Control System Fundamentals", The Control Handbook, CRC Press, Tayler and Francis Group, 2011.

3. Ashish Tewari, "Modern Control Design with Matlab and Simulink", John Wiley, New Delhi, 2002.
4. T. Glad and L. Ljung, "Control Theory – Multi variable and Nonlinear Methods", Taylor & Francis, 2002.
5. D. S. Naidu, "Optimal Control Systems" First Indian Reprint, CRC Press, 2009.

WEB RESOURCES:

1. https://nptel.ac.in/courses/108103007/#
2. https://www.slideshare.net/masmuhtadi/optimal-control-systems
3. http://www.cmapx.polytechnique.fr/~boscain/AUTOMATICS/introduction-to-optimal-control.pdf

OUTCOMES:

Upon completion of the course, the student should be able to

1. Design state feedback controller and state observer.
2. Understand and analyse linear and non-linear systems using phase plane method.
3. Understand and analyse non-linear systems using describing function methods.
4. Understand and design optimal controllers.
5. Understand optimal estimators including Kalman Filter.

CO-PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	3	1	1	-	-	-	-	-	1	1	3	2
CO2	2	1	2	2	1	-	-	-	-	1	1	1	2	2
CO3	2	3	2	1	-	-	1	-	-	-	1	1	2	3
CO4	2	2	1	3	1	-	-	1	-	1	1	1	3	2
CO5	2	2	2	2	1	1	-	1	-	-	1	1	2	2

PROFESSIONAL ELECTIVES - V

		L	T	P	C
24PPEEL312 SDG NO. 4,9&12	**MODERN POWER ELECTRONICS FOR TRACTION APPLICATIONS**	3	0	0	3

OBJECTIVES:

- To annotate the theoretical concepts of dynamics of electric tractions using modern power electronics

UNIT I FUNDAMENTALS OF ELECTRIC DRIVES 9

Basic concepts, Characteristics and operating modes of drive motors, Starting, braking and speed control of motors, Four quadrant drives, Nature and classification of load torque and associated controls used in Process industries, Selection of motors and rating.

UNIT II DC MOTOR DRIVES 9

Starting, braking and speed control, Analysis of separately excited DC motor with continuous armature current and discontinuous armature current, Analysis of DC series motor drives, Comparative evaluation of phase angle control, Semi-converter operation of full converter, Single phase half controlled and fully controlled rectifier fed DC motors, Sequence control, Three phase half controlled and fully controlled rectifier fed DC motors, Dual converter with circulating and non-circulating current controlled drives, Closed loop control system of DC motor drives, Reversible drives, Analysis and performance characteristics of chopper fed DC motors, Motoring and braking operations, Multiphase chopper, Phase locked loop control of dc drive.

UNIT III INDUCTION MOTOR DRIVES 9

Operation with unbalanced source voltages and unbalanced rotor impedances, Effect of time harmonics on the motor performance, Braking, Stator voltage control of induction motor, Variable Voltage Variable Frequency (VVVF) operation, Voltage Source Inverter (VSI) fed induction motor drive, Static rotor resistance control, Slip power recovery systems, closed loop control of ac drives, Introduction to field oriented control of ac motors, Comparison of ac and dc drive, Their selection for particular application.

UNIT IV ELECTRIC TRACTION 9

General features of electrical traction, Mechanics of train movement, Nature of traction load, Speed-time curves, Calculations of Traction drive rating and Energy consumption, Train resistance, Adhesive weight and Coefficient of Adhesion, Tractive effort for acceleration and propulsion, Power and Energy output from driving axles, Methods of speed control and braking of motors for traction load, Electric drive systems for electric traction.

UNIT V TRACTION MOTORS AND CONTROL 9

Desirable characteristics of Traction motors - Motors used for Traction purpose - Methods of starting and speed control of D.C Traction motors - Rheostatic Control - Energy saving with plain Rheostatic control - Series-parallel control - Energy saving with series parallel starting - Shunt Transition - Bridge-Transition- Drum control - Contactor type bridge Transition controller – Metadyne control - Multiple unit control - Regenerative braking.

TOTAL: 45 PERIODS

TEXTBOOKS

1. G.K. Dubey, "Fundamental of Electrical Drives", Narosa Publication, Reprint2015
2. B.K. Bose, "Power Electronics & Variable Frequency drive", IEEEpress,1997.
3. K. Pillai, "First Course on Electrical Drives", Wiley EasternLimited,1989.

REFERENCES

1. VedamSubramanyam, "Electric Drives– concepts and applications", Tata McGraw Hill,2011
2. C. Garg, "Utilization of Electrical Power and Electrical Traction", KhannaPublication.

WEB RESOURCES:

1. https://www.youtube.com/watch?time_continue=120&v=2Gjs7IPOCXs&feature=emb_title

ONLINE RESOURCES:

1. https://nptel.ac.in/courses/108/104/108104140/
2. https://nptel.ac.in/courses/108/104/108104011/
3. https://nptel.ac.in/courses/108/108/108108077/

OUTCOMES:

Upon completion of the course, the student should be able to

1. Analyze the power converters for traction applications.
2. Analyze the performance of DC motor Drives and induction motor drives for various operating conditions.
3. Estimate energy consumption rating of motor for traction application.

4. Study the concepts of electrical traction
5. Understand the control of traction motors

CO- PO,PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	2	2	-	1	-	-	-	-	1	1	2	2
CO2	2	1	2	2	1	1	-	-	-	-	1	1	2	2
CO3	2	2	2	2	-	1	-	-	-	-	1	1	2	2
CO4	2	1	1	1	-	1	-	-	-	-	1	1	2	2
CO5	2	1	1	1	-	1	-	-	-	-	1	1	2	2

Imagine the Future and

Make it happen!

1 NO POVERTY

2 ZERO HUNGER

3 GOOD HEALTH AND WELL-BEING

4 QUALITY EDUCATION

5 GENDER EQUALITY

6 CLEAN WATER AND SANITATION

7 AFFORDABLE AND CLEAN ENERGY

8 DECENT WORK AND ECONOMIC GROWTH

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

10 REDUCED INEQUALITIES

11 SUSTAINABLE CITIES AND COMMUNITIES

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

13 CLIMATE ACTION

14 LIFE BELOW WATER

15 LIFE ON LAND

16 PEACE, JUSTICE AND STRONG INSTITUTIONS

17 PARTNERSHIPS FOR THE GOALS

Sairam SDG ACTION PROGRAM

Together let's build a better world where there is NO POVERTY and ZERO HUNGER.

We have GOOD HEALTH AND WELL BEING QUALITY EDUCATION and full GENDER EQUALITY everywhere.

There is CLEAN WATER AND SANITATION for everyone. AFFORDABLE AND CLEAN ENERGY

which will help to create DECENT WORK AND ECONOMIC GROWTH. Our prosperity shall be fuelled

by investments in INDUSTRY, INNOVATION AND INFRASTRUCTURE that will help us to

REDUCE INEQUALITIES by all means. We will live in SUSTAINABLE CITIES AND COMMUNITIES.

RESPONSIBLE CONSUMPTION AND PRODUCTION will help in healing our planet.

CLIMATE ACTION will reduce global warming and we will have abundant,

flourishing LIFE BELOW WATER, rich and diverse LIFE ON LAND.

We will enjoy PEACE AND JUSTICE through STRONG INSTITUTIONS

and will build long term PARTNERSHIPS FOR THE GOALS.

For the goals to be reached, everyone needs to do their part: governments, the private sector, civil society and ***People like you.***

Together we can...

Sai Prakash Leo Muthu

CEO – Sairam Institutions