KSR College of Engineering

NAAC ACCREDITED A++ | NBA ACCREDITED PROGRAMMES

AN AUTONOMOUS INSTITUTION

M.E. - POWER ELECTRONICS AND DRIVES

Curriculum &
Syllabus for Semester I and II

REGULATIONS 2024

(Academic Year 2024-25 Onwards)

K.S.R. COLLEGE OF ENGINEERING: TIRUCHENGODE - 637 215

(Autonomous)

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

(REGULATIONS 2024)

Vision of the Institution

IV	We envision to achieve status as an excellent Educational Institution in the global knowledge hub, making self-learners, experts, ethical and responsible engineers, technologists, scientists, managers, administrators and entrepreneurs who will significantly contribute to research and environment friendly sustainable growth of the nation and the world.

Mission of the Institution

IM 1	To inculcate in the students self-learning abilities that enable them to become competitive and considerate engineers, technologists, scientists, managers, administrators and entrepreneurs by diligently imparting the best of education, nurturing environmental and social needs.
IM 2	To foster and maintain mutually beneficial partnership with global industries and Institutions through knowledge sharing, collaborative research and innovation.

Vision of the Department

DV	We envision a department that leads in the field of Electrical and Electronics Engineering through education, training and research committed to influence the direction of the field and make a constructive contribution to society wherein the Department can thrive and grow.

Mission of the Department

DM 1	To create professionally competent and resourceful Electrical and Electronics Engineers.
DM 2	To promote excellence in teaching, pioneering research, and innovation for the sustainable growth of the nation and enrichment of humanity.

Programme Educational Objectives (PEOs): M.E. - Power Electronics and Drives

The graduates of the programme will be able to

PEO 1	Excel in professional career with technical knowledge, skills and ability to design, develop and test power electronic converters and drives using advanced tools.
PEO 2	Technically competent and Exhibit leadership qualities to pursue career in broad area of Power Electronics and Drives globally.
PEO 3	Engage in life-long learning through independent study, projects, and research.

Programme Outcomes (POs) of M.E. - Power Electronics and Drives

Program Outcomes (POs)	
PO1	An ability to independently carry out research/investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

Programme Specific Outcomes (PSOs) of M.E. - Power Electronics and Drives

Program Specific Outcomes (PSOs)	
PSO1	Evaluate critically one's own work and make decisions by considering professional, social and ethical responsibilities.
PSO2	Recognize the need and engage in life-long learning through independent study, projects, research and to work in multidisciplinary teams.

KSR College of Engineering	K. S. R COLLEGE OF ENGINEERING (Autonomous) Approved by AICTE and Affiliated to Anna University, Chennai Accredited by NAAC ('A++' Grade) K.S.R. Kalvi Nagar, Tiruchengode - 637 215	CURRICULUM PG R 2024
Department	Department of Electrical and Electronics Engineering	
Programme	M.E. - Power Electronics and Drives	

SEMESTER – I												
Sl. No.	**Course Code**	**Course Name**	**Category**	**Hours/ Week**				**Credit**	**Maximum Marks**		
				L	**T**	**P**	**Tot**	**C**	**CA**	**ES**	**Total**
THEORY COURSES											
1.	MA24T17	Applied Mathematics (Common to PE, ET & CU)	FC	3	1	0	4	4	40	60	100
2.	RM24T19	Research Methodology and IPR	RMC	3	0	0	3	3	40	60	100
3.	PE24T11	Analysis of Power Converters	PCC	3	0	0	3	3	40	60	100
4.	PE24T12	Analysis of Inverters	PCC	3	0	0	3	3	40	60	100
5.	-	Professional Elective – I	PEC	3	0	0	3	3	40	60	100
6.	-	Professional Elective – II	PEC	3	0	0	3	3	40	60	100
LABORATORY COURSES											
7.	PE24P11	Power Electronics Simulation Laboratory – I	PCC	0	0	4	4	2	60	40	100
			Total	**18**	**1**	**4**	**23**	**21**	**700**		

SEMESTER – II											
Sl. No.	**Course Code**	**Course Name**	**Category**	**Hours/ Week**				**Credit**	**Maximum Marks**		
				L	**T**	**P**	**Tot**	**C**	**CA**	**ES**	**Total**
THEORY COURSES											
1.	PE24T21	Soft Computing Techniques (Common to PE & CU)	PCC	3	0	0	3	3	40	60	100
2.	PE24T22	Solid State DC Drives	PCC	3	0	0	3	3	40	60	100
3.	PE24T23	Solid State AC Drives	PCC	3	0	0	3	3	40	60	100
4.	PE24T24	FACTS Controllers	PCC	3	0	0	3	3	40	60	100
5.	-	Professional Elective – III	PEC	3	0	0	3	3	40	60	100
6.	-	Professional Elective – IV	PEC	3	0	0	3	3	40	60	100
LABORATORY COURSES											
7.	PE24P21	Power Electronics Simulation Laboratory – II	PCC	0	0	4	4	2	60	40	100
8.	PE24P22	Solid State Drives Laboratory	PCC	0	0	4	4	2	60	40	100
EMPLOYABILITY ENHANCEMENT COURSES											
9.	PE24P23	Technical Presentation	EEC	0	0	2	2	1	60	40	100
			Total	**18**	**0**	**10**	**28**	**23**	**900**		

SEMESTER – III											
Sl. No.	**Course Code**	**Course Name**	**Category**	**Hours/ Week**				**Credit**	**Maximum Marks**		
				L	**T**	**P**	**Tot.**	**C**	**CA**	**ES**	**Total**
THEORY COURSES											
1.	PE24T31	Electrical Energy Conservation and Management	PCC	3	0	0	3	3	40	60	100
2.	-	Professional Elective – V	PEC	3	0	0	3	3	40	60	100
3.	-	Open Elective	OEC	3	0	0	3	3	40	60	100
EMPLOYABILITY ENHANCEMENT COURSES											
4.	PE24P31	Project Work Phase – I	EEC	0	0	12	12	6	60	40	100
AUDIT COURSE											
5.	-	Audit Course	AC	2	0	0	2	0	100	-	100
Total				**11**	**0**	**12**	**23**	**15**	**500**		

SEMESTER – IV											
Sl. No.	**Course Code**	**Course Name**	**Category**	**Hours/ Week**				**Credit**	**Maximum Marks**		
				L	**T**	**P**	**Tot.**	**C**	**CA**	**ES**	**Total**
EMPLOYABILITY ENHANCEMENT COURSES											
1.	PE24P41	Project Work Phase – II	EEC	0	0	24	24	12	60	40	100
Total				**0**	**0**	**24**	**24**	**12**	**100**		
TOTAL NO. OF CREDITS = 71											
TOTAL NUMBER OF CREDITS TO BE EARNED FOR AWARD OF THE DEGREE = 71											
Note: FC – Foundation Courses, AC – Audit Courses, PCC – Professional Core Courses, PEC – Professional Elective Courses, EEC – Employability Enhancement Courses.											

FOUNDATION COURSES (FC)											
Sl. No.	**Course Code**	**Course Name**	**Category**	**Hours/Week**				**Credit**	**Maximum Marks**		
				L	**T**	**P**	**Tot.**	**C**	**CA**	**ES**	**Total**
1.	MA24T17	Applied Mathematics (Common to PE, ET & CU)	FC	3	1	0	4	4	40	60	100
			Total	**3**	**1**	**0**	**4**	**4**	**-**		

PROFESSIONAL CORE COURSES (PCC)											
Sl. No.	**Course Code**	**Course Name**	**Category**	**Hours/Week**				**Credit**	**Maximum Marks**		
				L	**T**	**P**	**Tot.**	**C**	**CA**	**ES**	**Total**
1.	PE24T11	Analysis of Power Converters	PCC	3	0	0	3	3	40	60	100
2.	PE24T12	Analysis of Inverters	PCC	3	0	0	3	3	40	60	100
3.	PE24P11	Power Electronics Simulation Laboratory – I	PCC	0	0	4	4	2	60	40	100
4.	PE24T21	Soft Computing Techniques (Common to PE & CU)	PCC	3	0	0	3	3	40	60	100
5.	PE24T22	Solid State DC Drives	PCC	3	0	0	3	3	40	60	100
6.	PE24T23	Solid State AC Drives	PCC	3	0	0	3	3	40	60	100
7.	PE24T24	FACTS Controllers	PCC	3	0	0	3	3	40	60	100
8.	PE24P21	Power Electronics Simulation Laboratory – II	PCC	0	0	4	4	2	60	40	100
9.	PE24P22	Solid State Drives Laboratory	PCC	0	0	4	4	2	60	40	100
10.	PE24T31	Electrical Energy Conservation and Management	PCC	3	0	0	3	3	40	60	100
			TOTAL	**21**	**0**	**12**	**33**	**27**	**-**		

RESEARCH METHODOLOGY AND IPR COURSES (RMC)											
S. No.	**Course Code**	**Course Title**	**Category**	**Periods / Week**				**Credit**	**Max. Marks**		
				L	**T**	**P**	**Tot.**		**CA**	**ES**	**Total**
1.	RM24T19	Research Methodology and IPR	RMC	3	0	0	3	3	40	60	100
			TOTAL	**3**	**0**	**0**	**3**	**3**	**-**		

EMPLOYABILITY ENHANCEMENT COURSES (EEC)											
Sl. No.	**Course Code**	**Course Name**	**Category**	**Hours/Week**				**Credit**	**Maximum Marks**		
				L	**T**	**P**	**Tot.**	**C**	**CA**	**ES**	**Total**
1.	PE24P23	Technical Presentation	EEC	0	0	2	2	1	60	40	100
2.	PE24P31	Project Work Phase – I	EEC	0	0	12	12	6	60	40	100
3.	PE24P41	Project Work Phase – II	EEC	0	0	24	24	12	60	40	100
			Total	**0**	**0**	**38**	**38**	**19**	**-**		

PROFESSIONAL ELECTIVE – I & II (SEMESTER – I)											
Sl. No.	**Course Code**	**Course Name**	**Category**	**Hours/ Week**				**Credit**	**Maximum Marks**		
				L	**T**	**P**	**Tot**	**C**	**CA**	**ES**	**Total**
THEORY COURSES											
1.	PE24E01	Advanced Power Semiconductor Devices	PEC	3	0	0	3	3	40	60	100
2.	PE24E02	Non-Conventional Energy Sources	PEC	3	0	0	3	3	40	60	100
3.	PE24E03	High Voltage DC Transmission System	PEC	3	0	0	3	3	40	60	100
4.	PE24E04	Protection for Electrical Drives	PEC	3	0	0	3	3	40	60	100
5.	PE24E05	Embedded System Design	PEC	3	0	0	3	3	40	60	100
6.	PE24E06	Energy Storage Technologies	PEC	3	0	0	3	3	40	60	100
7.	PE24E07	Modeling of Electrical Machines	PEC	3	0	0	3	3	40	60	100
8.	ET24E04	System Design using Microcontroller (Common to PE & ET)	PEC	3	0	0	3	3	40	60	100
			Total	**24**	**0**	**0**	**24**	**24**	**-**		

PROFESSIONAL ELECTIVE – III and IV (SEMESTER – II)											
Sl. No.	**Course Code**	**Course Name**	**Category**	**Hours/ Week**				**Credit**	**Maximum Marks**		
				L	**T**	**P**	**Tot**	**C**	**CA**	**ES**	**Total**
THEORY COURSES											
1.	PE24E08	Special Machines	PEC	3	0	0	3	3	40	60	100
2.	PE24E09	PWM Techniques for Power Converters	PEC	3	0	0	3	3	40	60	100
3.	PE24E10	Power Quality Management	PEC	3	0	0	3	3	40	60	100
4.	PE24E11	System Theory	PEC	3	0	0	3	3	40	60	100
5.	PE24E12	Industrial Robotics	PEC	3	0	0	3	3	40	60	100
6.	PE24E13	Advanced Digital Signal Processing	PEC	3	0	0	3	3	40	60	100
7.	PE24E14	Power Electronics in Wind & Solar Power Conversion	PEC	3	0	0	3	3	40	60	100
8.	PE24E15	Electric Vehicles	PEC	3	0	0	3	3	40	60	100
			Total	**24**	**0**	**0**	**24**	**24**	-		

PROFESSIONAL ELECTIVE – V (SEMESTER – III)											
Sl. No.	**Course Code**	**Course Name**	**Category**	**Hours/ Week**				**Credit**	**Maximum Marks**		
				L	**T**	**P**	**Tot**	**C**	**CA**	**ES**	**Total**
THEORY COURSES											
1.	PE24E16	Smart Grid (Common to PE & ET)	PEC	3	0	0	3	3	40	60	100
2.	PE24E17	Machine Learning	PEC	3	0	0	3	3	40	60	100
3.	PE24E18	Application of MEMS Technology	PEC	3	0	0	3	3	40	60	100
4.	PE24E19	Digital Signal Processors and Applications	PEC	3	0	0	3	3	40	60	100
5.	PE24E20	Industrial Drives and Applications	PEC	3	0	0	3	3	40	60	100
6.	PE24E21	Distributed Generation and Micro Grid	PEC	3	0	0	3	3	40	60	100
7.	PE24E22	Virtual Instrumentation System (Common to PE & ET)	PEC	3	0	0	3	3	40	60	100
Total				**21**	**0**	**0**	**21**	**21**	**-**		

AUDIT COURSES (SEMESTER – III)											
Sl. No.	**Course Code**	**Course Name**	**Category**	**Hours/ Week**				**Credit**	**Maximum Marks**		
				L	**T**	**P**	**Tot**	**C**	**CA**	**ES**	**Total**
THEORY COURSES											
1.	AX24A01	Disaster Management	AC	2	0	0	2	0	100	--	100
2.	AX24A02	Value Education	AC	2	0	0	2	0	100	--	100
3.	AX24A03	Constitution of India	AC	2	0	0	2	0	100	--	100
4.	AX24A04	Indian Knowledge System	AC	2	0	0	2	0	100	--	100
			TOTAL	**8**	**0**	**0**	**8**	**0**	**---**		

OPEN ELECTIVE COURSES OFFERED BY OTHER DEPARTMENTS											
Sl. No.	**Course Code**	**Course Name**	**Category**	**Hours/ Week**				**Credit**	**Maximum Marks**		
				L	**T**	**P**	**Tot.**	**C**	**CA**	**ES**	**Total**
THEORY COURSES											
1.	CS24O01	Machine learning and Deep Learning	OEC	3	0	0	3	3	40	60	100
2.	CS24O02	Blockchain and Crypto Currency	OEC	3	0	0	3	3	40	60	100
3.	CS24O03	Multimedia Technologies	OEC	3	0	0	3	3	40	60	100
4.	BD24O01	Big Data Analytics	OEC	3	0	0	3	3	40	60	100
5.	BD24O02	Internet of Things and Cloud	OEC	3	0	0	3	3	40	60	100
6.	BD24O03	Big Data Visualization	OEC	3	0	0	3	3	40	60	100
7.	ET24O01	Embedded Systems	OEC	3	0	0	3	3	40	60	100
8.	ET24O02	Embedded Control	OEC	3	0	0	3	3	40	60	100
9.	ET24O03	Embedded Automation	OEC	3	0	0	3	3	40	60	100
10.	IT24O01	IoT for Smart System	OEC	3	0	0	3	3	40	60	100
11.	IT24O02	Machine Learning for Intelligent Multimedia Analytics	OEC	3	0	0	3	3	40	60	100
12.	IT24O03	DevOps and Microservices	OEC	3	0	0	3	3	40	60	100
13.	IT24O04	Cyber security and Digital Awareness	OEC	3	0	0	3	3	40	60	100
14.	CN24O01	Energy Efficient Building	OEC	3	0	0	3	3	40	60	100
15.	CN24O02	Economics and Finance Management in Construction	OEC	3	0	0	3	3	40	60	100
16.	CN24O03	Stress management	OEC	3	0	0	3	3	40	60	100
17.	ST24O01	Principles of Sustainable Development	OEC	3	0	0	3	3	40	60	100
18.	ST24O02	Failure Analysis of Structures	OEC	3	0	0	3	3	40	60	100
19.	ST24O03	Smart materials and Smart Structures	OEC	3	0	0	3	3	40	60	100
20.	CU24O01	Principles of Multimedia	OEC	3	0	0	3	3	40	60	100
21.	CU24O02	Software Defined Radio	OEC	3	0	0	3	3	40	60	100
22.	CU24O03	MEMS & NEMS	OEC	3	0	0	3	3	40	60	100
23.	CU24O04	Introduction to cognitive Radio Network	OEC	3	0	0	3	3	40	60	100
24.	CC24O01	Digital Manufacturing	OEC	3	0	0	3	3	40	60	100
25.	CC24O02	Design for Manufacturing and Assembly	OEC	3	0	0	3	3	40	60	100
26.	CC24O03	Smart Materials and Structures	OEC	3	0	0	3	3	40	60	100

Sl. No.	Course Code	Course Name	Category	Hours/ Week				Credit	Maximum Marks		
				L	T	P	Tot.	C	CA	ES	Total
27.	IS24O01	Industrial Safety Engineering	OEC	3	0	0	3	3	40	60	100
28.	IS24O02	Fire Engineering and Protection	OEC	3	0	0	3	3	40	60	100
29.	IS24O03	Food and Bio-safety	OEC	3	0	0	3	3	40	60	100
OPEN ELECTIVE COURSES OFFERED TO OTHER DEPARTMENTS											
1.	PE24O01	Switching Concepts and Power Semiconductor Devices	OEC	3	0	0	3	3	40	60	100
2.	PE24O02	Smart Grid Technology	OEC	3	0	0	3	3	40	60	100
3.	PE24O03	Renewable Energy Technology	OEC	3	0	0	3	3	40	60	100
4.	PE24O04	Energy Management and Conservation	OEC	3	0	0	3	3	40	60	100

COURSE COMPONENT SUMMARY

S. No.	Category	Credits Per Semester				Credits Total	Percentage Credits
		I	II	III	IV		
1.	FC	4	-	-	-	4	5.63
2.	RMC	3	-	-	-	3	4.23
3.	PCC	8	16	3	-	27	38.02
4.	PEC	6	6	3	-	15	21.12
5.	EEC	-	1	6	12	19	26.76
6.	OEC	-	-	3	-	3	4.23
7.	Audit Course	-	-	√	-	-	-
TOTAL		**21**	**23**	**15**	**12**	**71**	**100**

MA24T17	APPLIED MATHEMATICS	Category	L	T	P	C
		FC	3	1	0	4

(Common to PE, ET & CU)

PREREQUISITE:

Students should have the strong foundation in mathematical concepts including Linear Algebra, Probability theory and Statistics, familiarity with Mathematical modeling and Numerical methods techniques.

OBJECTIVES:

- To equip students to apply matrix decomposition methods.
- To enable students to translate real-world problems into linear programming problems and implement solutions effectively.
- To provide insights into methods to analyze discrete and continuous random variables.
- To develop the ability to analyze the basic components and behaviour of queuing systems.
- To acquire the skills to apply and formulate to solve boundary value problems in ordinary differential equations.

UNIT - I	MATRIX THEORY	(9+3)

Matrix factorizations – The Cholesky decomposition – QR factorization – Least squares method – Singular value decomposition – Toeplitzmatrices and some applications.

UNIT - II	LINEAR PROGRAMMING PROBLEMS	(9+3)

Formulation of LPP – Graphical method – Simplex method – Big M method – Two Phase Simples method – Dual Simplex method.

UNIT - III	ONE-DIMENSIONAL RANDOM VARIABLE	(9+3)

One dimensional random variable – Discrete and continuous random variables – Probability mass function and probability density function – Expectations – Moments – Moment generating functions and their properties – Binomial, Poisson, Uniform, Exponential and Normal distributions.

UNIT - IV	QUEUING MODELS	(9+3)

Characteristics of queuing models – Kendall's notations – Little's formula – (M/M/1): $(\infty/FIFO)$ Single server with infinite capacity – (M/M/C): $(\infty/FIFO)$ Multi-server with infinite capacity – (M/M/1): $(N/FIFO)$ Single server with finite capacity – (M/M/C): $(N/FIFO)$ Multi-server with finite capacity.

UNIT - V	COMPUTATIONAL METHODS IN ENGINEERING	(9+3)

Boundary value problems for ODE – Classification of PDE – Solution of Laplace and Poisson equations – Liebmann's iteration process – Solution of heat conduction equation by Bender Schmidt explicit formula and Crank Nicolson implicit scheme – Solution of the wave equation.

TOTAL (L:45, T:15) = 60 PERIODS

COURSE OUTCOMES:

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

COs	Course Outcome	Cognitive Level
CO1	Apply and decompose matrices effectively.	Apply
CO2	Create models and formulate linear programming problems.	Analyze
CO3	Analyze and work with a single random variable.	Analyze
CO4	Analyze and interpret the key features of various queuing systems.	Analyze
CO5	Set up and solve boundary value problems for ODEs.	Apply

TEXT BOOKS:

1. Johnson R. A. and Gupta C. B., ‘Miller & Freund’s Probability and Statistics for Engineers’, Pearson Education, Eighth Edition, 2015.
2. Grewal, B.S., ‘Higher Engineering Mathematics’, Khanna Publishers, Forty-Fourth Edition, 2017.

REFERENCES:

1. Bronson, R., ‘Schaum’s Outline Series of Matrix Operations’, McGraw-Hill Education, Second Edition, 2011.
2. Hamdy, A Taha., ‘Operations research. An introduction’, Pearson Edition, Tenth Edition, 2017.
3. Donald Gross and Carl M. Harris, ‘Fundamentals of Queuing Theory’, John Wiley and Sons, Fourth Edition, 2013.
4. Kandasamy, P., Thilagavathy and Gunavathy, K., ‘Numerical Methods’, S. Chand & Company Ltd, Third Edition, 2003.

Mapping of COs with POs and PSOs

COs/ POs	PO1	PO2	PO3	PSO1	PSO2
CO1	3	-	-	3	-
CO2	3	-	-	3	-
CO3	3	-	-	3	-
CO4	3	-	-	3	-
CO5	3	-	-	3	-
Avg.	**3**	**-**	**-**	**3**	**-**

1- Low, 2- Medium, 3- High

RM24T19	**RESEARCH METHODOLOGY AND IPR**	**Category**	**L**	**T**	**P**	**C**
		RMC	**3**	**0**	**0**	**3**

(Common to PED, EST, CSE, BDA, CAD CAM, ISE)

PREREQUISITE:

A basic understanding of academic writing and critical thinking skills to analyze research literature, familiarity with fundamental statistical concepts for data analysis, and a strong grasp of core subject knowledge relevant to the student's field. Additionally, a general awareness of legal principles related to intellectual property, ethical research practices, and innovation trends will enhance the student's ability to engage with both research methodologies and IPR concepts.

OBJECTIVES:

- To equip students with the ability to design and conduct rigorous research, employing appropriate methodologies, and critically analyzing results.
- To foster the ability to critically evaluate academic literature, identify research gaps, and formulate research questions.
- To enable students to effectively communicate research findings and legal arguments, both in written form and through presentations, to academic and professional audiences.
- To instill an understanding of ethical issues in research, including responsible conduct, data integrity, and the ethical use of intellectual property.
- To provide a comprehensive understanding of intellectual property rights, including patents, trademarks, copyrights, and their application in various industries.

UNIT - I	**RESEARCH DESIGN**	**(9)**

Overview of research process and design – Use of secondary and exploratory data to answer the research question, Qualitative research, Observation studies – Experiments and surveys.

UNIT - II	**DATA COLLECTION AND SOURCES**	**(9)**

Measurements: Measurement scales – Questionnaires and instruments – Sampling and Methods. Data – Preparing, Exploring, Examining and Displaying.

UNIT - III	**DATA ANALYSIS AND REPORTING**	**(9)**

Overview of multivariate analysis – Hypotheses testing and measures of association – Presenting insights and findings using written reports and oral presentation.

UNIT - IV	**INTELLECTUAL PROPERTY RIGHTS**	**(9)**

Intellectual Property – The concept of IPR, Evolution and development of the concept of IPR, IPR development process, Trade secrets, Utility models, IPR & Biodiversity, Role of WIPO and WTO in IPR establishments, Right of property, Common rules of IPR practices, Types and features of IPR agreement, Trademark, Functions of UNESCO in IPR maintenance.

UNIT - V	**PATENTS**	**(9)**

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
COs	**Course Outcome**	**Cognitive Level**
CO1	Develop a suitable research process to solve real-time problems.	Apply
CO2	Apply appropriate methods to collect qualitative and quantitative data for analysis.	Apply
CO3	Apply appropriate statistical tools to analyze data and solve research problems.	Apply
CO4	Describe the types and features of intellectual property and its role in IPR establishment.	Apply
CO5	Illustrate the patent procedures, E-filling, register of patents, and licensing of patents.	Apply

TEXT BOOKS:	
1	Cooper Donald, R., Schindler Pamela, S., and Sharma, J.K., “Business Research Methods”, Tata McGraw Hill Education, Eleventh Edition, 2012.
2	Catherine J. Holland, Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets, Entrepreneur Press, 2007.
REFERENCES:	
1	David Hunt, Long Nguyen, Matthew Rodgers, Patent Searching: Tools & Techniques, Wiley, 2007.
2	The Institute of Company Secretaries of India, Statutory body under an Act of Parliament, Professional Programme Intellectual Property Rights, Law and Practice, September 2013.

Mapping of COs with POs and PSOs

COs/ POs	**PO1**	**PO2**	**PO3**	**PSO1**	**PSO2**
CO1	3	3	-	1	1
CO2	3	3	-	1	1
CO3	3	3	-	1	1
CO4	3	3	-	1	1
CO5	3	3	-	1	1
Avg.	**3**	**3**	**-**	**1**	**1**
1 - Low, 2 - Medium, 3 - High					

<table>
<tr><td rowspan="2">PE24T11</td><td rowspan="2">ANALYSIS OF POWER CONVERTERS</td><td>Category</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>PCC</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
</table>

PREREQUISITE:

Fundamental electronics concepts, including semiconductor devices (e.g., diodes, transistors, MOSFETs), passive components (resistors, capacitors, inductors), and basic circuit theory. Knowledge of basic converter types (e.g., rectifiers, inverters, DC-DC converters) and their operational principles. Proficiency in analyzing electrical circuits, including the ability to apply Kirchhoff's laws, perform nodal and mesh analysis, and solve circuit parameters.

OBJECTIVES:

- To enable students to utilize the fundamental principles of single-phase controlled rectifiers in calculating and analyzing key performance parameters.
- To calculate and derive key performance parameters such as output voltage, current, power factor, and total harmonic distortion for different firing angles.
- To identify and explain the key differences and similarities between various resonant converter topologies.
- To enable students to grasp and articulate the basic principles underlying the operation of switch-mode converters.
- To identify and describe each step in the design process of switch-mode converters, including requirements analysis, component selection, and design validation.

UNIT - I	**SINGLE-PHASE CONTROLLED RECTIFIERS**	**(9)**

Static V-I characteristics of Silicon Controlled Rectifier (SCR) – Single-phase half-controlled and fully-controlled converters with R, RL, RLE loads and freewheeling diodes – Continuous and discontinuous modes of operation – Inverter operation – Performance parameters: harmonics, ripple, distortion, power factor – Effect of source impedance – Single-phase dual converter with R load.

UNIT - II	**THREE-PHASE CONTROLLED RECTIFIERS**	**(9)**

Need and advantages of three-phase controlled rectifiers – Semi and fully controlled converter with R, RL, RLE loads and freewheeling diodes – Inverter operation and its limit – Performance parameters: harmonics, ripple, distortion, power factor – Effect of source impedance – Three-phase dual converter with R load.

UNIT - III	**RESONANT CONVERTERS**	**(9)**

Introduction – Classification of resonant converters – Basic resonant circuit concepts – Load resonant converters – Resonant switch converters – Zero voltage switching topology – Zero current switching topology – Application of resonant converters.

UNIT - IV	**SWITCH MODE CONVERTERS**	**(9)**

Introduction to switching power supplies – Non-isolated switch mode DC-DC converters: Buck converter, Boost converter, Buck-Boost converter, Cuk converter, SEPIC and Zeta converters – Comparison of non-isolated switch mode DC-DC converters – Isolated switch mode DC-DC converters: Single switch isolated DC-DC converters, Multiple switch isolated DC-DC converters – Comparison of isolated switch mode DC-DC converters.

UNIT - V	**DESIGN OF SWITCHED-MODE CONVERTERS**	**(9)**

Design of magnetic materials and cores – Copper windings – Thermal considerations – Design of inductor, Design of capacitor, Design of transformer and transformer leakage inductance – Design of feedback compensators – Unity power factor rectifiers, Resistor emulation principle and applications to rectifiers.

TOTAL: 45 PERIODS

COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
COs	**Course Outcome**	**Cognitive Level**
CO1	Apply the fundamental principles of single-phase controlled rectifiers to derive performance parameters under different firing angles.	Apply
CO2	Determine key performance parameters of three-phase controlled rectifiers under different firing angles and load conditions.	Apply
CO3	Expound the fundamental principles and operational characteristics of different resonant converters.	Apply
CO4	Interpret the fundamental principles and operational characteristics of switch-mode converters.	Apply
CO5	Exemplify the design process of switch-mode converters.	Apply

TEXT BOOKS:

1.	Rashid, M.H., Power Electronics Circuits, Devices and Applications, Fourth Edition, Prentice Hall India, New Delhi, 2023.
2.	Ned Mohan, Undeland and Robbin, Power Electronics: Converters, Application and Design, Third Edition, John Wiley and Sons. Inc, Newyork, 2009.

REFERENCES:

1.	Bimbra,P.S., Power Electronics, Seventh Edition, Khanna Publishers, 2022.
2.	Andrzej M.Trzynadlowski, Introduction to Modern Power Electronics, Third Edition, John Wiley & Sons, 2015.
3.	Issa Batarseh, Power Electronic Circuits, Second Edition, John Wiley, 2004.
4.	Singh, M.D., Khanchandani, K.B., Power Electronics, Second Edition, McGraw Hill, 2017.

Mapping of COs with POs and PSOs

COs/ POs	**PO1**	**PO2**	**PO3**	**PSO1**	**PSO2**
CO1	3	-	3	2	2
CO2	3	-	3	2	2
CO3	3	-	3	2	2
CO4	3	-	3	2	2
CO5	3	-	3	2	2
Avg.	**3**	**-**	**3**	**2**	**2**

1- Low, 2- Medium, 3- High

<table>
<tr><td rowspan="2">PE24T12</td><td rowspan="2">ANALYSIS OF INVERTERS</td><td>Category</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>PCC</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
</table>

PREREQUISITE:

Students should have a concept of basic electrical engineering principles, including the understanding of voltage, current, resistance and ohm's law. Additionally, with semiconductor devices, such as diodes, transistors and MOSFETs, are required as these components are fundamental to inverter technology.

OBJECTIVES:

- To provide the electrical circuit concepts behind the different working modes of inverters so as to enable deep understanding of their operation.
- To understand and comprehend the various operating modes of different configurations of Inverters.
- To impart knowledge on multilevel inverters.
- To advance concept series and parallel resonant inverters.
- To understand the various types of inverter control strategies.

UNIT - I	**SINGLE PHASE INVERTERS**	**(9)**

Static characteristics of MOSFET and IGBT – Principle of single-phase half and full bridge inverters – Performance parameters – Voltage control of single-phase inverters: Single, Multi-pulse, Sinusoidal, Space vector modulation techniques – Single phase current source inverters – Application to drive system.

UNIT - II	**THREE PHASE INVERTERS**	**(9)**

Three-phase inverter: 180 degree and 120 degree conduction mode – Performance parameters – Voltage control of three-phase inverters – Inverter operation modes – Load commutated inverter –Application to drive system.

UNIT - III	**MULTILEVEL INVERTERS**	**(9)**

Multilevel concept – Advantages of multilevel inverters – Single-phase and three-phase multilevel inverter: Diode clamped, Flying capacitor and Cascaded type multilevel inverters – Comparison of multilevel inverters – Application of multilevel.

UNIT - IV	**RESONANT INVERTERS**	**(9)**

Series and parallel resonant inverters – Voltage control of resonant inverters – Class E resonant inverter – Resonant DC-link inverters.

UNIT - V	**CONTROL STRATEGIES OF INVERTER**	**(9)**

Inverter Switching: Unipolar, Bipolar, Inverter, Dead time – Analysis of Inverter modulation: Sine triangle modulation, Trapezoidal modulation and Third harmonic modulation – Comparison of sine triangle and third harmonic modulation – Output filter requirement for different PWM Techniques.

Total (L: 45) = 45 PERIODS

COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
COs	**Course Outcome**	**Cognitive Level**
CO1	Elucidate the operating principle of various types of single-phase inverters.	Understand
CO2	Design and analyze the operation of three-phase inverters with various conduction modes.	Understand
CO3	Describe the design of multilevel inverters for industrial applications.	Understand
CO4	Develop an efficient system using resonant and soft-switching inverters.	Apply
CO5	Summarize the various types of inverter control strategies.	Understand

TEXT BOOKS:

1	Rashid, M.H., Power Electronics Circuits, Devices, and Applications, Prentice Hall India, New Delhi, Fourth Edition, 2023.
2	Ned Mohan, Undeland Robbin, Power Electronics: Converters, Application and Design, John Wiley and Sons. Inc, Newyork, Third Edition, 2023.

REFERENCES:

1	Philip T. Krein, Elements of Power Electronics, Scand Publishing, New Delhi, Second Edition, 2017.
2	Jai P.Agrawal, Power Electronics System Theory and Design, Pearson Education, Second Edition, 2015.
3	Krishna Kumar Gupta, Pallavee Bhatnagar, Multilevel Inverters Conventional and Emerging Topologies and Their Control, Elsevier Science, 2017.
4	Bimbra, P.S., Power Electronics, Khanna Publishers, Seventh Edition, 2022.

Mapping of COs with POs and PSOs

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	2	3	-	3
CO2	3	2	3	-	3
CO3	3	2	3	-	3
CO4	3	2	3	-	3
CO5	3	2	3	-	3
Avg.	**3**	**2**	**3**	**-**	**3**

1- Low, 2- Medium, 3- High

PE24P11	POWER ELECTRONICS SIMULATION LABORATORY – I	Category	L	T	P	C
		PCC	0	0	4	2

PREREQUISITE:

Basic knowledge of electrical concepts such as voltage, current, resistance, inductance, and capacitance. Operation of semiconductor devices like diodes, transistors (BJT, MOSFET, IGBT), thyristors, etc. Basic control theory, including feedback control and stability analysis. Experience with software like MATLAB/Simulink, PSpice, or similar tools used for circuit simulation.

OBJECTIVES:

- To effectively simulate the electrical characteristics and behaviors of power diodes and SCR.
- To analyze the performance of single-phase and three-phase converters.
- To evaluate the performance of a single-phase dual converter using simulation software.
- To observe the performance of single-phase and three-phase inverters equipped with a PWM controller.
- To evaluate the performance of single-phase multilevel inverters using MATLAB.

LIST OF EXPERIMENTS:

1.	Modeling of power diodes using MATLAB Simulink.
2.	Modeling of SCR using MATLAB Simulink.
3.	Simulation of a single-phase semi-controlled converter.
4.	Simulation of a single-phase fully-controlled converter.
5.	Simulation of a three-phase semi-controlled converter.
6.	Simulation of a three-phase fully-controlled converter.
7.	Simulation of a single-phase dual converter.
8.	Simulation of a single-phase full bridge Inverter.
9.	Simulation of a three-phase full bridge inverter.
10.	Simulation of a single-phase multilevel inverter.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

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

COs	Course Outcome	Cognitive Level
CO1	Simulate the model of the power diode and SCR.	Apply
CO2	Simulate the single-phase and three-phase converters.	Apply
CO3	Evaluate the performance of a single-phase dual converter using simulation.	Apply
CO4	Observe the performance of single and three-phase inverters with a PWM controller.	Apply
CO5	Assess the performance of a single-phase multilevel inverter.	Apply

REFERENCES:

1. Amos Gilat, "MATLAB: An Introduction with Applications", Fourth Edition, Wiley, 2012.
2. Farzin Asadi, "Simulation of Power Electronics Circuits with MATLAB®/Simulink®, Design, Analyze, and Prototype Power Electronics", First Edition, Apress Berkeley, CA, 2022.

Mapping of COs with POs and PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5
CO1	3	2	3	1	3
CO2	3	2	3	1	3
CO3	3	2	3	1	3
CO4	3	2	3	1	3
CO5	3	2	3	1	3
Avg.	**3**	**2**	**3**	**1**	**3**

1- Low, 2- Medium, 3- High

PE24T21	SOFT COMPUTING TECHNIQUES	Category	L	T	P	C
		PCC	3	0	0	3

(Common to PE & CU)

PREREQUISITE:

Familiarity with basic machine learning concepts (such as supervised and unsupervised learning, classification, regression, clustering) is helpful as soft computing techniques often deal with these areas and it creates a strong foundation in basic algorithms (sorting, searching, optimization) and) will help in grasping more complex algorithms like genetic algorithms and neural networks.

OBJECTIVES:

- To understand the basic concepts of soft computing and its difference from traditional computing techniques.
- To gain knowledge about the fundamentals of artificial neural networks, including their architectures, learning mechanisms, and applications.
- To acquire the skills to learn the concepts of fuzzy logic, fuzzy sets, and their use in dealing with uncertainty and imprecision in real-world problems.
- To develop the ability to analyze and learn the concepts of fuzzy logic, fuzzy sets, and their use in dealing with uncertainty and imprecision in real-world problems.
- To enable the students to understand evolutionary algorithms, particularly genetic algorithms, and their applications in solving optimization and search problems.

UNIT - I	**ARTIFICIAL NEURAL NETWORK**	**(9)**

Biological neural networks – Artificial neural networks – Common activation functions – McCulloch-pitts neuron – Hebb Net – Perceptron – Linear separability – Perceptron learning rule – Delta rule.

UNIT-II	**NEURAL NETWORK ARCHITECTURE AND ALGORITHMS**	**(9)**

Backpropagation Neural Net: Standard and counter back propagation – Hopfield neural net: Discrete and Continuous – Associative memory neural networks – Boltzman machine – Case study: Power system voltage Stability assessment through an artificial neural network.

UNIT-III	**COMPETITIVE NEURAL NETWORKS**	**(9)**

Fixed-weight competitive nets – Maxnet – Mexican Hat Net – Kohonen self-organizing Maps – Adaptive Resonance Theory – Neuro controllers – Functional diagram – Inverse dynamics.

UNIT-IV	**FUZZY LOGIC SYSTEM**	**(9)**

Fuzzy sets – Properties of classical and fuzzy sets – Operations on fuzzy sets – Fuzzy relations – Linguistic variables – Linguistic hedges – Fuzzy rule base – Fuzzy logic controller – Fuzzification – Membership functions – Defuzzification – Case study: Control of electrical drives based on fuzzy logic.

UNIT-V	**EVOLUTIONARY PROGRAMMING**	**(9)**

Optimization methods – Genetic algorithm – Real coded GA – Particle swarm optimization – Lion optimization.

TOTAL = 45 PERIODS

COURSE OUTCOMES:

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

COs	Course Outcome	Cognitive Level
CO1	Infer the concepts of artificial neural networks.	Understand
CO2	Explicate the architecture and algorithms of BPN, Hopfield and apply the knowledge to voltage stability problems.	Apply
CO3	Understand the concept of competitive neural networks and apply the knowledge to develop neuro controllers.	Apply
CO4	Discuss the concepts of fuzzy logic systems with classical systems; apply the knowledge of fuzzy logic controllers for classical applications.	Apply
CO5	Illustrate the fundamentals of genetic algorithm, Particle swarm optimization, Lion optimization and its various functionalities.	Understand

TEXT BOOKS:

1	Sivanandam, S.N and Deepa S.N, Principles of Soft Computing, John Wiley and Sons Ltd, United States, Third Edition, 2018.
2	Jacek.M.Zurada, Introduction to Artificial Neural Systems, Jaico Publishing House, Third Edition, 2006.

REFERENCES:

1	Lawrence Faussett, Fundamental of neural networks, Prentice Hall, First Edition, 2004.
2	J. Ross, Fuzzy Logic with Engineering Applications, John Wiley and Sons, Third Edition, 2011.
3	S, Rajasekaran, G.A. Vijayalakshmi Pai, Neural Networks, Fuzzy systems and evolutionary algorithms: Synthesis and Applications, PHI Publication, Second Edition 2017.
4	David E. Goldberg, Genetic Algorithm in Search Optimization and Machine Learning, Pearson Education, New Delhi, Thirteenth Edition, 2013.

Mapping of COs with POs and PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5
CO1	-	-	-	-	-
CO2	-	-	-	-	-
CO3	3	1	-	1	1
CO4	3	1	-	1	1
CO5	3	1	-	1	1
Avg.	**3**	**1**	**-**	**1**	**1**

1- Low, 2- Medium, 3- High

PE24T22	SOLID STATE DC DRIVES	L	T	P	C
		3	0	0	3

PREREQUISITE:

A foundational knowledge in Ohm's Law, Kirchhoff's Laws, basic circuit components and the operation of semiconductor devices, inverters and rectifiers, DC motor and its characteristics, speed and torque control DC Motor. Differential Equations skills is useful for understanding the dynamic systems and control theory. Knowledge of braking systems and safety standards used to protect the DC drive.

OBJECTIVES:

- To gain knowledge about analyzing the multi-quadrant operation and characteristics of DC motor and mechanical system
- To develop the ability to analyze the operation of the converter-fed DC drive
- To provide adequate skill to analyze the operation of the chopper-fed DC drive
- To infer the knowledge about the design of current and speed controllers for a closed loop solid-state DC motor drive.
- To understand the concept of different braking systems applied to phase and chopper-controlled DC drive

UNIT - I **DC MOTORS FUNDAMENTALS AND MECHANICAL SYSTEM** **(9)**

DC motor – Types, induced EMF, speed-torque relations – Speed control: Armature, field speed control and 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 – multi-quadrant operation, drive elements, types of motor duty and selection of motor rating.

UNIT - II **CONVERTER CONTROL DC DRIVES** **(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 operation – Current ripple and its effect on performance – Operation with freewheeling diode – Dual converter fed DC drives.

UNIT - III **CHOPPER CONTROL DC DRIVES** **(9)**

Introduction about chopper, control strategy – Class A, B, C, D and E chopper-controlled DC motor – Performance analysis – Multi quadrant control – Chopper-based implementation of braking methods, Multi-phase chopper; Related problems

UNIT - IV **CLOSED-LOOP CONTROL** **(9)**

Modeling of drive elements – Equivalent circuit, transfer function of separately excited DC motors, model of power converters – Sensing and feedback elements – Closed loop control of armature and field control – PLL and microcomputer control of dc drives.

UNIT - V **BRAKING OF DC DRIVES** **(9)**

Different braking methods – Dynamic and Regenerative braking Methods of phase-controlled and chopper-controlled DC separately excited and series motors – DC drives in transit systems

TOTAL = 45 PERIODS

COURSE OUTCOMES:

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

COs	Course Outcome	Cognitive Level
CO1	Summarize the basic concept of steady-state operation and transient dynamics of a motor load system	Apply
CO2	Determine the performance and parameters of converter-controlled DC drives	Apply
CO3	Determine the performance and parameters of chopper-controlled DC drives	Apply
CO4	Apply the closed-loop control of DC drives.	Apply
CO5	Infer the various braking schemes of phase-controlled and chopper-controlled DC drives	Apply

TEXT BOOKS:

1	Vedam Subramanyam, Electric Drives - Concepts and Applications, McGraw Hill, India, Second Edition, 2011.
2	Gobal K.Dubey, Fundamentals of Electrical Drives, Narosa Publishing House, New Delhi, Second Edition, 2020.

REFERENCE BOOKS:

1	Krishnan.R, Electric Motor Drives – Modeling, Analysis and Control, Prentice-Hall of India Pvt. Ltd., New Delhi, 2010.
2	Gopal K Dubey, Power Semiconductor Controlled Drives, Prentice Hall Inc., New York, Second Edition, 1993.
3	RRamapraba, R., and Seyezhai, R., Solid state drives DC and AC, Scitech Publications Private Limited, India, First Edition, 2020.
4	Bimal K Bose, Modern Power Electronics and AC Drives, Pearson Education India, Uttar Pradesh, First Edition, 2015.

Mapping of COs with POs and PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	2	2
CO2	3	2	2	2	2
CO3	3	2	2	2	2
CO4	3	2	2	2	2
CO5	3	2	2	2	2
Avg.	**3**	**2**	**2**	**2**	**2**

1- Low, 2- Medium, 3- High

PE24T23	**SOLID STATE AC DRIVES**	**Category**	**L**	**T**	**P**	**C**
		PCC	**3**	**0**	**0**	**3**

PREREQUISITE:

A solid basis in the fundamental concepts of AC circuit analysis, and electrical machines, and control systems in electrical engineering. Strong mathematical abilities are essential for evaluating power electronics in ac drives and simulation tools. These include proficiency in linear algebra, matrix operations, differential equations, and complex numbers.

OBJECTIVES:

- To gain knowledge about the steady state operation and transient dynamics of a motor load system.
- To gain proficiency in the concept of CSI and VSI-fed induction motor control.
- To acquire the skills to analyze the operation for field-oriented fed induction motor control.
- To develop the operation of direct torque control of the induction motor.
- To enable the synchronous motor drives and their performance.

UNIT - I	**PERFORMANCE OF AC 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, Slip power recovery – Static Kramer Drive – Synchronous Drives.

UNIT - II	**VSI AND CSI-FED INDUCTION MOTOR CONTROL**	**(9)**

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

UNIT - III	**FIELD ORIENTED CONTROL**	**(9)**

Field-oriented control of induction machines – Theory – DC drive analogy – Direct or feedback vector control, Indirect or feed-forward vector control – Flux vector estimation – Space vector modulation control.

UNIT - IV	**DIRECT TORQUE CONTROL**	**(9)**

Direct torque control of induction machines – Torque expression with stator and rotor fluxes, DTC control strategy – Optimum switching vector selection – reduction or torque ripple methods.

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

COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
COs	**Course Outcome**	**Cognitive Level**
CO1	Discover the steady-state operation and transient dynamics of a motor load system.	Understand
CO2	Elucidate the concept of CSI and VSI-fed induction motor control.	Understand
CO3	Describe the operation for field-oriented fed induction motor control.	Understand
CO4	Interpret the operation of direct torque control of the induction motor.	Understand
CO5	Develop the synchronous motor drives and their performance.	Understand

TEXT BOOKS:	
1	Bimal K. Bose, Modern Power Electronics and AC Drives, Pearson Education, Asia, Reprint, First Edition, 2015.
2	Gopal K. Dubey, Power Semiconductor Controlled Drives, Prentice Hall Inc., New Jersey, First Edition, 1999.

REFERENCES:	
1	Vedam Subramanyam, Electric Drives–Concepts and Applications, Tata McGraw Hill, Second Edition, 2017.
2	Krishnan, R., Electric Motor Drives–Modeling, Analysis and Control, Prentice-Hall of India Pvt. Ltd., New Delhi, First Edition, 2010.
3	Leonhard, W., Control of Electrical Drives, Narosa Publishing House, Second Edition, 1992.
4	P.Vas, ‘Sensorless Vector and Direct Torque Control’, Oxford University Press, New York, Second Edition, 1998.

Mapping of COs with POs and PSOs

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	2	2	1	-	3
CO2	3	2	1	-	3
CO3	3	2	2	-	1
CO4	2	2	2	-	1
CO5	3	2	2	-	3
Avg.	**2.6**	**2**	**1.6**	**-**	**2.2**

1- Low, 2- Medium, 3- High

<table>
<tr><td rowspan="2">PE24T24</td><td rowspan="2">FACTS CONTROLLERS</td><td>Category</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>PCC</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
</table>

PREREQUISITE:

Basic knowledge of power electronics and power systems, including power system dynamics and control. FACTS controllers are a group of resources that help overcome limitations in the dynamic and static transmission capacity of electrical networks. They can provide series compensation to the reactance of lines, or shunt compensation to transmission lines. FACTS controllers can also act as actuators in control schemes to dampen interarea oscillations.

OBJECTIVES:

- To understand the fundamental principles of FACTS technologies, which enhance the controllability and stability of AC transmission systems.
- To gain a comprehensive grasp of the Static VAR Compensator (SVC) technology, including its components and basic operation.
- To Learn the fundamental principles of TCSC & GCSC including their structure and operation.
- To Study the innovations and advancements in FACTS technologies and how they differ from traditional FACTS devices.
- To Study how different FACTS devices interact with each other and with the overall control system.

UNIT - I	**INTRODUCTION**	**(9)**

The concept of flexible AC transmission - Reactive power control in electrical power transmission lines – Uncompensated transmission line – Series and shunt compensation. Overview of FACTS devices: Static VAR Compensator (SVC) – Thyristor Switched Series Capacitor (TCSC) – Unified Power Flow Controller (UPFC) – Integrated Power Flow Controller (IPFC).

UNIT - II	**STATIC VAR COMPENSATOR (SVC) AND APPLICATIONS**	**(9)**

Methods of controllable VAR generation – Switching converter type VAR generators – Basic operating principle and control approaches – Voltage control by SVC – Dynamic characteristics – Sign of SVC voltage regulator – Modelling of SVC for power flow and transient stability Applications: Enhancement of transient stability – Steady state power transfer – Prevention of voltage instability.

UNIT - III	**THYRISTOR AND GTO CONTROLLED SERIES CAPACITOR (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	**EMERGING FACTS CONTROLLERS**	**(9)**

Principle of operation Static Synchronous Compensator (STATCOM) – V-I Characteristics. Applications: Enhancement of transient stability – Prevention of voltage instability. SSSC operation of SSSC and the control of power flow – Modeling of SSSC in load flow and transient stability studies. Applications: SSR mitigation – UPFC and IPFC – comparison of different FACTS controllers.

UNIT - V	**CO-ORDINATION OF FACTS CONTROLLERS**	**(9)**

Controller interactions – Control coordination using genetic algorithms – SVC-SVC interaction – Co-ordination of multiple controllers using linear control techniques – Advancements in FACTS controllers and their co-ordination.

Total = 45 PERIODS

COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
COs	**Course Outcome**	**Cognitive Level**
CO1	Explain the various FACTS controllers operation on FACTS systems.	Understand
CO2	Categorize the different VAR compensation techniques.	Understand
CO3	Illustrate the concepts of TCSC & GCSC and its applications.	Understand
CO4	Apply the concept of voltage source converter-based FACTS controller.	Apply
CO5	Explain the coordination of FACTS controllers in different controllers.	Understand

TEXT BOOKS:

1	Mohan Mathur, R., Rajiv K. Varma, Thyristor – Based Facts Controllers for Electrical Transmission Systems, IEEE press and John Wiley and Sons, Student Edition, 2011.
2	Narain, G. Hingorani, Understanding FACTS – Concepts and Technology of Flexible AC Transmission Systems, Standard Publishers Distributors, Delhi - 110006, First Edition, 2000.

REFERENCES:

1	Padiyar, K.R., FACTS Controllers in Power Transmission and Distribution, New Age International Pvt. Limited, Publishers, New Delhi, Second Edition, 2016.
2	John, A.T., Flexible A.C. Transmission Systems, Institution of Electrical and Electronic Engineers, 1999.
3	Vijay K. Sood, HVDC and FACTS controllers – Applications of Static Converters in Power Systems, Kluwer Academic Publishers, First Edition, 2012.
4	Enrique Acha, Claudio R. Fuerte-Esquivel, Hugo Ambriz-Pérez, "FACTS: Modelling and Simulation in Power Networks", John Wiley, 2011.

Mapping of COs with POs and PSOs

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	2	-	3	2
CO2	3	2	-	3	2
CO3	3	2	-	3	2
CO4	3	2	-	3	2
CO5	3	2	-	3	2
Avg.	**3**	**2**	**-**	**3**	**2**

1- Low, 2- Medium, 3- High

PE24P21	POWER ELECTRONICS SIMULATION LABORATORY – II	Category	L	T	P	C
		PCC	0	0	4	2

PREREQUISITE: Completion of an introductory course in power electronics covering basic concepts, components (e.g., diodes, transistors, MOSFETs, IGBTs), and circuit configurations. Basic understanding of electrical machines and their operation, as well as knowledge of drive systems and their integration with power electronics. Knowledge of basic control systems principles, such as feedback loops, controllers, and their application in power electronics systems.

OBJECTIVES:

- To grasp the fundamental operation and principles of buck, boost, and buck-boost converters, including their voltage conversion ratios and operational modes.
- To perform the detailed analysis of series resonant converter circuits, including calculating key parameters such as resonant frequency, voltage and current waveforms, and impedance characteristics.
- To analyze the key performance metrics of closed-loop DC drives such as speed control accuracy, torque response, system stability, efficiency, and transient behavior.
- To recognize the operation of the chopper circuit in regulating the DC motor's voltage and current, and analyzing how different chopper configurations affect drive performance.
- To comprehend the fundamental components and operational principles of standalone PV systems, including solar panels, charge controllers, batteries, and inverters.

LIST OF EXPERIMENTS:

1.	Simulation of MOSFET / IGBT-based step-down chopper with R load.
2.	Simulation of MOSFET / IGBT-based step-up chopper with R load.
3.	Simulation of DC-DC buck-boost converter with R load.
4.	Simulation of series resonant converter with R load.
5.	Closed loop control of buck converter fed DC motor drive using simulation.
6.	Closed loop control of boost converter fed DC motor drive using simulation.
7.	Closed loop control of buck-boost Converter fed DC motor drive using simulation.
8.	Simulation of closed-loop control of BLDC motor drive.
9.	Simulation of four quadrant chopper fed DC motor drive.
10.	Simulation of stand-alone PV systems.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

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

COs	Course Outcome	Cognitive Level
CO1	Simulate the buck, boost, and buck-boost converter with R load.	Apply
CO2	Evaluate the performance of a series resonant converter.	Apply
CO3	Evaluate the performance of closed-loop controller-based DC drive.	Apply
CO4	Observe the performance of the four-quadrant chopper-fed DC motor drive.	Apply
CO5	Discriminate the performance of standalone PV systems.	Apply

REFERENCES:

1. Amos Gilat, “MATLAB: An Introduction with Applications”, Fourth Edition, Wiley, 2012.
2. Farzin Asadi, “Simulation of Power Electronics Circuits with MATLAB®/Simulink®, Design, Analyze, and Prototype Power Electronics”, First Edition, Apress Berkeley, CA, 2022.

Mapping of COs with POs and PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5
CO1	3	2	3	1	3
CO2	3	2	3	1	3
CO3	3	2	3	1	3
CO4	3	2	3	1	3
CO5	3	2	3	1	3
Avg.	**3**	**2**	**3**	**1**	**3**

1 - Low, 2 - Medium, 3 - High

PE24P22	SOLID STATE DRIVES LABORATORY	Category	L	T	P	C
		PCC	0	0	4	2

PREREQUISITE:

A foundational understanding of electrical circuits, magnetic principles, and motor operation is necessary to grasp the concepts of electric drives and knowledge of power semiconductor devices and conversion techniques is important for managing the power supply and efficiency of electric drive systems.

OBJECTIVES:

- To analyze the performance of AC and DC motor drives using simulation tools in the MATLAB environment.
- To examine the performance of AC and DC motor drives by implementing speed control and performance analysis using a microcontroller-based system.
- To observe and analyze the performance of Switched Reluctance Motors and Brushless DC motors using a DSP-based controller for speed control.
- To evaluate the performance of a three-phase Space Vector Pulse Width Modulation (SVPWM) inverter using IGBT switch.
- To analyze the performance of an induction motor by implementing control algorithms using an FPGA controller.

LIST OF EXPERIMENTS:

1.	Simulation of four quadrant operation of three-phase induction motor.
2.	Simulation of Automatic Voltage Regulation of three-phase synchronous generator.
3.	Microcontroller based speed control of converter fed DC motor.
4.	Microcontroller based speed control of chopper fed DC motor.
5.	Microcontroller based speed control of VSI fed three–phase induction motor.
6.	Microcontroller based speed control of Stepper motor.
7.	DSP based speed control of BLDC motor.
8.	DSP based speed control of SRM motor.
9.	IGBT based three-phase SVPWM Inverter.
10.	FPGA based speed control of VSI fed Induction Motor.

TOTAL: 60PERIODS

COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
COs	**Course Outcome**	**Cognitive Level**
CO1	Determine the drive performance of AC motor and DC motor using MATLAB environment.	Apply
CO2	Investigate the drive performance of AC motor and DC motor using a Microcontroller.	Apply
CO3	Observe the performance of SRM Motors and BLDC motor using DSP controller.	Apply
CO4	Evaluate the performance of a three-phase SVPWM Inverter using IGBT.	Apply
CO5	Determine the performance of the induction motor using FPGA controller.	Apply

REFERENCES:

1.	Farzin Asadi, 'Simulation of Power Electronics Circuits with MATLAB/Simulink, Design, Analyze, and Prototype Power Electronics', First Edition, Apress Berkeley, CA, 2022.
2.	N. Mohan, T. M. Undeland, and W. P. Robbins, 'Power electronics, converters, applications and design,' John Wiley & Sons, Inc, 2016.

Mapping of COs with POs and PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	2	2
CO2	3	2	2	2	2
CO3	3	2	2	2	2
CO4	3	2	2	2	2
CO5	3	2	2	2	2
Avg.	**3**	**2**	**2**	**2**	**2**

1- Low, 2- Medium, 3- High

PE24P23	TECHNICAL PRESENTATION	Category	L	T	P	C
		EEC	0	0	2	1

PREREQUISITE:

Students should have a core grasp of the subject matter connected to their area of study to efficiently prepare and deliver technical presentations. This understanding should include a fundamental comprehension of research methodologies, the ability to write reports, and familiarity with key technical ideas.

OBJECTIVES:

- To enable students to critically review and recognize key challenges in their field of interest, enabling distinct study and the development of new solutions.
- To facilitate students to explore particular topics or areas of interest via complete literature evaluation, including journals, conference proceedings, and other academic sources.
- To bridge the gap between theoretical knowledge and practical application by enhancing students' ability to apply learned concepts to solve real-time problems effectively and collaboratively.
- To enhance their understanding of a topic by having them present and receive feedback on their findings.
- To equip students with the skills needed to effectively communicate their research and ideas through structured report writing and professional presentations related to their area of study.

The students should adhere to the following Guidelines:

- The students have to refer to the journals and conference proceedings and collect the published literature.
- By mutual discussions with the faculty in-charge the student can decide on a topic related to the area/topic.
- The student is expected to collect at least 20 such research papers published in the last 5 years.
- Using OHP / PowerPoint, the student has to make a presentation for 20 minutes followed by 10 minute discussion.
- The student has to make five presentations in the semester.
- The student has to write a technical report for about 30 - 50 pages (Title page, One-page Abstract, Review of Research paper under various sub-headings, concluding remarks, and list of references). The technical report has to be submitted to the course coordinator one week before the final presentation, after the approval of the faculty in-charge.

TOTAL: 30 PERIODS

COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
COs	**Course Outcome**	**Cognitive Level**
CO1	Familiarize the problems in general areas of interest to the student.	Understand
CO2	Identify the area/problem by referring to journals, conference proceedings, etc.	Analyze
CO3	Enhance the collective skills between theoretical knowledge and real-time problems.	Create
CO4	Gain knowledge on the problem by presentation and review.	Understand
CO5	Acquire ideas on report writing and presentation.	Understand

Mapping of COs with POs and PSOs					
COs/ POs	**PO1**	**PO2**	**PO3**	**PSO1**	**PSO2**
CO1	2	3	3	3	2
CO2	2	3	3	3	2
CO3	2	3	3	3	2
CO4	2	3	3	3	2
CO5	2	3	3	3	2
Avg.	**2**	**3**	**3**	**3**	**2**
1 - Low, 2 - Medium, 3 - High					

PE24E01	ADVANCED POWER SEMICONDUCTOR DEVICES	Category	L	T	P	C
		PCC	3	0	0	3

PREREQUISITE:

The fundamentals of semiconductor materials, such as the concepts of doping, p-n junctions, and carrier dynamics, is crucial. Along with knowledge of basic low power electronic components and circuits, including diodes, transistors (BJTs, MOSFETs, IGBTs), thyristors, and their operation principles are required. Familiarity with the principles of power conversion and control, including rectifiers, inverters, and converters. This includes understanding how power devices are used in practical circuits. Proficiency in mathematics and physics are needed, as these are often required for understanding device modelling and simulation.

OBJECTIVES:

- To explore criteria for selecting appropriate power devices for various applications, and gain insight into recent advancements and emerging technologies in power devices, such as wide-band gap materials (SiC, GaN).
- To learn about different types of current-controlled devices, their fundamental operating principles and characteristics of these devices.
- To acquire knowledge on types of voltage-controlled devices, their fundamental operating principles, characteristics and applications of these devices.
- To study about various protection mechanisms to safeguard power devices from overvoltage, overcurrent, and thermal stress.
- To gain awareness about the concept of thermal considerations and thermal management techniques specific to power devices.

UNIT - I	OVERVIEW OF POWER DEVICES	(9)

Power switching devices overview – Attributes of an ideal switch, application requirements, circuit symbols, Power handling capability – Safe Operating Area – Power diodes: Types, forward and reverse characteristics, switching characteristics, rating – Features and brief history of Silicon Carbide (SiC) – Promise and demonstration of SiC power devices – Physical properties of SiC devices – Unipolar and Bipolar power diodes.

UNIT - II	CURRENT CONTROLLED DEVICES	(9)

BJT's: Construction, static and switching characteristics, negative temperature coefficient and second breakdown – Thyristors :Construction, working, static and transient characteristics, series and parallel operation – comparison of BJT and Thyristor – steady state models of BJT &Thyristor – Basics of GTO – SiC based bipolar devices(BJTs and Thyristors) – GaN technology overview – Building a GaN transistor –GaN transistor electrical characteristics.

UNIT - III	VOLTAGE CONTROLLED DEVICES	(9)

Principle of voltage controlled devices – Construction, static and switching characteristics: Power MOSFETs, IGBTs and IGCTs – Steady state models of MOSFETs, IGBTs and IGCTs – Intelligent power modules –Study of modules like APTGT100TL170G, MSCSM70TAM05TPAG – SiC based unipolar devices (MOSFETs and JFETs).

UNIT - IV	DEVICE SELECTION, DRIVING AND PROTECTING CIRCUITS	(9)

Device selection strategy – On-state and switching losses – EMI due to switching – Necessity of isolation – pulse transformer, opto-coupler – Gate drive circuit: SCR, MOSFET, IGBTs –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, vapour and phase cooling – Guidance for heat sink selection – Thermal resistance and impedance – Electrical analogy of thermal components, heat sink types and design – Mounting types – switching loss calculation for power devices.		
		Total = 45 PERIODS

COURSE OUTCOMES:

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

COs	Course Outcome	Cognitive Level
CO1	Identify the suitable power devices for various applications.	Understand
CO2	Interpret the characteristics of current controlled devices.	Understand
CO3	Infer the characteristics of voltage-controlled Silicon devices.	Understand
CO4	Discover proper driving circuits and protection circuits.	Apply
CO5	Construct a proper thermal protective device for power semiconductor devices.	Apply

TEXT BOOKS:

1. Rashid M.H., "Power Electronics Circuits, Devices and Applications", Pearson Education, fourth Edition, Tenth Impression, 2021.
2. Mohan, Undeland and Robins, "Power Electronics: Converters Applications and Design", Media Enhanced, Third Edition, Wiley, 2007.

REFERENCES:

1. B.W Williams, "Power Electronics Circuit Devices and Applications", McGraw Hill Higher Education, Second edition, 1992.
2. Tsunenobu Kimoto and James A. Cooper, "Fundamentals of Silicon Carbide Technology: Growth, Characterization, Devices, and Applications", John Wiley & Sons Singapore Pvt. Ltd, First Edition, 2014.
3. Alex Lidow, Johan Strydom, Michael de Rooij and David Reusch, "GaN Transistors for efficient power conversion", Second Edition, Wiley, 2015.
4. Biswanath Paul, "Power Electronics", New edition, Universities Press, 2019.

Mapping of COs with POs and PSOs

COs/ POs	PO1	PO2	PO3	PSO1	PSO2
CO1	3	2	-	-	-
CO2	3	2	-	-	-
CO3	3	2	-	-	-
CO4	3	2	-	-	-
CO5	3	2	-	-	-
Avg.	3	2	-	-	-

1 - Low, 2 - Medium, 3 - High

<table>
<tr><td rowspan="2">PE24E02</td><td rowspan="2">NON-CONVENTIONAL ENERGY SOURCES</td><td>Category</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>PEC</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
</table>

PREREQUISITE:

A strong foundation in fundamentals of energy, basic chemistry, power systems, fluid mechanics, thermodynamics and material science. Mathematical skills in calculus, statistics, algebra and Probability for modeling and analyzing energy production and consumption. Knowledge in Electrical Systems is used for understanding electrical circuits, power electronics, and integration of energy systems with the grid.

OBJECTIVES:

- To develop the ability to analyze and design a PV system
- To acquire knowledge about the utilization of wind energy system
- To enable students to select and apply appropriate fuel cell technology & hydrogen energy for a given application
- To provide adequate knowledge about ocean thermal electric conversion and tidal energy
- To infer the concept of Geothermal and Biomass energy conversion resources and applications.

UNIT - I **SOLAR ENERGY** **(9)**

Solar energy: solar radiation, availability, measurement and estimation – Solar thermal conversion devices and storage – solar cells and photo voltaic conversion – PV systems – MPPT – Applications of PV Systems – Solar energy collectors and storage.

UNIT - II **WIND ENERGY** **(9)**

Basic principles of wind energy conversion – wind data and energy estimation – site selection consideration – basic components of wind energy conversion system – Types of wind turbines – Schemes for electric generations – Generator control, load control, energy storage – Applications of wind energy – Interconnected systems.

UNIT - III **CHEMICAL ENERGY SOURCES** **(9)**

Design and principles of operation of a fuel cell –Types of fuel cells – conversion efficiency of fuel cells – Types of electrodes, work output and EMF of fuel cell – Applications of fuel cells. Hydrogen energy: Introduction – Hydrogen production: Electrolysis, Thermochemical, Electrochemical, Westing house sulphur cycle – Hydrogen storage – Utilization of hydrogen gas.

UNIT - IV **ENERGY FROM OCEANS** **(9)**

Ocean Thermal Electric Conversion (OTEC): open cycle OTEC system, closed OTEC cycle – Energy from tides: Basic principles of tidal power - component of tidal power plants - operation methods of utilization of tidal energy - site requirements – storage – advantages and limitations of tidal power generation. Ocean waves, energy and power from the waves, wave energy conversion devices.

UNIT - V **ENERGY FROM GEO THERMAL AND BIOMASS** **(9)**

Estimation of geothermal power – nature of geothermal fields – geothermal sources – inter connection of geothermal fossil systems – prime movers for geothermal energy conversion – Application of geothermal energy – Energy from biomass: Introduction, Biomass conversion technologies, photosynthesis – classification of biogas plants – Biomass Energy conversion – Energy from waste (Municipal solid waste)

TOTAL = 45 PERIODS

COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
COs	**Course Outcome**	**Cognitive Level**
CO1	Develop PV systems and implement MPPT in PV systems.	Apply
CO2	Confer the various configurations of wind energy conversion systems	Apply
CO3	Familiarize with the concept of energy from Fuel cells and Hydrogen	Understand
CO4	Deliberate the energy tapping methods from ocean sources and tidal energy.	Understand
CO5	Summarize the concept of geo-thermal and biomass energy.	Apply

TEXT BOOKS:

1	Rai, G.D., Non-Conventional Energy Sources, Khanna Publishers, New Delhi, Third Edition, 2022.
2	John Twidell and Tony Weir, Renewable Energy Resources, Taylor & Francis, London, Third Edition, 2015.

REFERENCES:

1	Sukhatme, S.P and Nayak J.K., Solar Energy, Tata McGraw Hill Education, India, Fourth Edition, 2017.
2	Tiwari, G.N., and Ghosal, M.K., Renewable Energy Resources: Basic Principles and Applications, Narosa Publishing House, New Delhi, Second Edition, 2005.
3	Shobh Nath Singh, Non-conventional Energy resources, Pearson Education, India, First Edition, 2015.
4	Yogi Goswami, D., Principles of Solar Engineering, CRC Press, Taylor and Francis Group, London, Third Edition, 2000.

Mapping of COs with POs and PSOs

COs/ POs	**PO1**	**PO2**	**PO3**	**PSO1**	**PSO2**
CO1	3	2	1	1	2
CO2	3	2	1	1	2
CO3	3	2	1	1	2
CO4	3	2	1	1	2
CO5	3	2	1	1	2
Avg.	**3**	**2**	**1**	**1**	**2**

1 - Low, 2 - Medium, 3 - High

PE24E03	HIGH VOLTAGE DC TRASMISSION SYSTEM	Category	L	T	P	C
		PEC	3	0	0	3

PREREQUISITE:

High-voltage direct current (HVDC) transmission systems use DC to transmit electrical power over long distances, unlike more common AC systems. The main components of an HVDC system are converter stations, transmission media and electrodes.

OBJECTIVES:

- To acquire knowledge of both AC and DC transmission, highlighting the advantages, challenges and applications of HVDC systems.
- To understand the design, operational principles, performance parameters and impact on the overall HVDC transmission system.
- To study the different types of MTDC systems, their control strategies and the protection mechanisms necessary to ensure reliable and efficient operation.
- To learn the principles of power conversion, ensuring efficient and stable operation and managing power flow between the AC and DC sides of the system.
- To identify, evaluate and select appropriate simulation techniques that are best suited for analyzing various aspects of HVDC system design, performance and operation.

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	ANALYSIS OF HVDC CONVERTERS	(9)

Analysis of HVDC Converters, Rectifier and Inverter operation of Graetz circuit without and with overlap. Output voltage waveforms and DC voltage in rectifier and inverter operation, Equivalent circuit of HVDC link.

UNIT - III	MULTI-TERMINAL DC SYSTEMS	(9)

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

UNIT - IV	POWER FLOW ANALYSIS IN AC/DC SYSTEMS	(9)

Per unit system for DC Quantities – Modelling of DC links – Solution of DC load flow – Solution of AC-DC power flow – Case studies.

UNIT - V	SIMULATION OF HVDC SYSTEMS	(9)

Introduction – System simulation: Philosophy and tools – HVDC system simulation – Modeling of HVDC systems for digital dynamic simulation – Dynamic interaction between DC and AC systems.

TOTAL = 45 PERIODS

COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
COs	**Course Outcome**	**Cognitive Level**
CO1	Explain the concept of electrical power transmission systems and the performance of HVDC systems.	Understand
CO2	Determine the configuration and characteristics of HVDC converters.	Understand
CO3	Apply the concept of multi-terminal DC systems types, control and protection.	Apply
CO4	Implement the power flow in the AC to DC system.	Understand
CO5	Discriminate the method of simulation in the HVDC system.	Understand

TEXT BOOKS:

1	K.R. Padiyar, HVDC Power Transmission Systems, New Age International Pvt. Ltd., New Delhi, Reprint 2005.
2	Jos.Arrillaga, High Voltage Direct Current Transmission, Peter Pregrinus, London, Second Edition, 1998.

REFERENCES:

1	P. Kundur, Power System Stability and Control, McGraw-Hill, Second Edition, 2022.
2	Erich Uhlmann, Power Transmission by Direct Current, BS Publications, Reprint 2015.
3	Vijay K. Sood, HVDC and FACTS controllers – Applications of Static Converters in Power Systems, Kluwer Academic Publishers, First Edition, 2012.
4	Kamakshaiah, S and Kamaraju, V, ‘HVDC Transmission’, Tata McGraw Hill Education, New delhi, First Edition, 2011.

Mapping of COs with POs and PSOs

COs/ POs	PO1	PO2	PO3	PSO1	PSO2
CO1	2	3	-	3	-
CO2	2	3	-	3	-
CO3	2	3	-	3	-
CO4	2	3	-	3	-
CO5	2	3	-	3	-
Avg.	**2**	**3**	**-**	**3**	**-**

1 - Low, 2 - Medium, 3 - High

PE24E04	PROTECTION FOR ELECTRICAL DRIVES	Category	L	T	P	C
		PEC	3	0	0	3

PREREQUISITE:

Students should have a concept in electrical engineering fundamentals, including knowledge of electrical circuits, power systems, and protection schemes. Proficiency in the operation and characteristics of electrical drives and their control systems is essential. A good understanding of power electronics, including the functioning of semiconductor devices used in drives, is required. Additionally, students should be skilled in the application of protection methods and evaluate protection systems for various types of electrical drives.

OBJECTIVES:

- To understand the concept of programmable logic controllers.
- To develop the modeling of the electrical drive system.
- To analyze and work with the concepts of digital and numerical relaying of various power apparatuses.
- To understand the DC drive protection scheme.
- To advance the concept of an AC drive protection scheme.

UNIT - I	PROGRAMMABLE LOGIC CONTROLLERS (PLC)	(9)

Evolution of modern PLC – Relay-based PLC – Microprocessor-based PLC – Input and output modules – Other functional elements – Personal computer as PLC – Programming the PLC – Communication in PLC – Typical applications of PLC – PID control capability in programmable controllers.

UNIT - II	MODELLING OF DRIVE SYSTEM	(9)

Mathematical modeling of a drive system – First order, second order process – Analysis of closed-loop control system – Stability analysis – Controllability and observability of time invariant systems – Design of control algorithm using Z transform – PID algorithms – Design for load changes.

UNIT - III	DIGITAL PROTECTION	(9)

Numerical relay – Sampling frequency – Digital signal processing – Digital filtering in protective relays – Relays algorithms – Over current relays, Directional relay, Impedance relay, MHO relay, Differential relay.

UNIT - IV	DC DRIVE PROTECTION	(9)

Overvoltage protection of power controllers feeding DC drives: Origin of voltage transients – Suppression of voltage transients – Delayed commutation – Commutation overlap – Protection against failure of commutation in AC-DC converter and DC-DC chopper feeding a DC drive – Protection against failure of field – Short circuit protection – Protection against over speed – Protection against fluctuating loads – Drive instability – Development of schemes for above types of drive protection.

UNIT - V	AC DRIVE PROTECTION	(9)

Protection against over-voltage and under-frequency in AC drives – Protection against over current due to acceleration and deceleration – Protection against failure of commutation in inverters, cycloconverters and AC voltage controller feeding AC drives – Protection against over speed.

Total = 45 PERIODS

COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
COs	**Course Outcome**	**Cognitive Level**
CO1	Describe the programmable logic controllers used for the protection of electrical drives.	Understand
CO2	Summarize the modeling of the electrical drive system.	Apply
CO3	Discuss different digital protection relays.	Understand
CO4	Illustrate the DC drive protection scheme.	Understand
CO5	Describe the AC drive protection scheme.	Understand

TEXT BOOKS:

1	Y.G. Paithankar and S.R Bhide, Fundamentals of Power System Protection, PHI Learning Pvt. Ltd, Second Edition, 2022.
2	Michal P Lucas, Distributed Control Systems, Van Noster and Reinhold Co, New Delhi, Second Edition, 2016.

REFERENCES:

1	Ravindra P. Singh, Digital Power System Protection, Prentice-Hall of India Pvt. Ltd, Second Edition, 2022.
2	Vedam Subramaniam, Electrical Drive and Control, New Age International (P) Ltd., New Delhi, Second Edition, 2017.
3	S. Chakraborthy, Gupta and Bhatnagar, Power System Engineering, D.Rai Publishing, Third Edition,2017.
4	S.B. Dewan, G.R. Slemon, and A. Straughen, Power semiconductor drives, John Wiley and Sons, New York, Second Edition 2017.

Mapping of COs with POs and PSOs

COs/ POs	**PO1**	**PO2**	**PO3**	**PSO1**	**PSO2**
CO1	3	1	-	3	3
CO2	3	1	-	3	3
CO3	3	1	-	3	3
CO4	3	1	-	3	3
CO5	3	1	-	3	3
Avg.	**3**	**1**	**-**	**3**	**3**

1 - Low, 2 - Medium, 3 - High

PE24E05	EMBEDDED SYSTEM DESIGN	Category	L	T	P	C
		PEC	3	0	0	3

PREREQUISITE:

A strong foundation in electronics is necessary for designing and implementing the hardware components of embedded systems. To build efficient and reliable systems, it's crucial to understand the principles of embedded systems design, including hardware-software co-design and system architecture. Proficiency in languages like C, C++, and assembly is vital for writing efficient code and optimizing system performance.

OBJECTIVES:

- To explore the fundamental requirements of embedded systems and the interaction between hardware and software.
- To illustrate the architecture of a PIC microcontroller and various interfacing circuits.
- To introduce the architecture of ARM processors and instruction sets.
- To acquire knowledge of the basics of real-time operating systems.
- To provide an overview of design verification methods that are adopted for embedded system design and case study.

UNIT - I	OVERVIEW OF EMBEDDED SYSTEM	(9)

Embedded systems description, definition, design considerations & requirements – Overview of Embedded system Architecture – Classification of embedded systems – Purpose of the embedded system – Embedded system Design Life Cycle – Major application of the embedded system.

UNIT - II	PIC MICROCONTROLLER 16F87X	(9)

Architecture – Features – Resets – Memory Organizations: Program Memory, Data Memory – Instruction Set – Interrupts – I/O Ports – Timers – CCP Modules – Master Synchronous Serial Port (MSSP) – USART – ADC – I^2C.

UNIT - III	ARM PROCESSORS	(9)

ARM processor – Processor and memory organization – Data operations – CPU Bus configuration – ARM Bus – ARM Architecture – ARM Programmers model – ARM Development tools – ARM assembly language programming – ARM Instruction Set – Thumb instruction set – Embedded ARM Applications.

UNIT - IV	REAL-TIME OPERATING SYSTEMS	(9)

Operating system services – I/O subsystems – Network operating systems – Interrupt Routines in RTOS Environment – RTOS task scheduling models – Interrupt – Performance Metric in scheduling models – IEEE standard POSIX functions for standardization of RTOS – Inter task communication functions – List of Basic functions in a preemptive scheduler – Fifteen-point strategy for synchronization between processors – OS Functions and Tasks – OS security issues – Mobile OS.

UNIT - V	SYSTEM DESIGN TECHNIQUES	(9)

Design Methodologies – Requirement Analysis and Specification – System Analysis and Architecture Design – Quality Assurance – Case Study: Adaptive cruise control – Emission control system – Navigation systems – In-vehicle communication system.

TOTAL = 45 PERIODS

COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
COs	**Course Outcome**	**Cognitive Level**
CO1	Illustrate the basic concepts of embedded systems.	Understand
CO2	Familiarize the concepts of PIC microcontrollers.	Understand
CO3	Elucidate the ARM processor with various configurations.	Understand
CO4	Apply operation of system services in real-time applications.	Apply
CO5	Gain knowledge about various design examples in system design.	Apply

TEXT BOOKS:	
1	Shibu, S.K.V., Introduction to Embedded system, Tata McGraw Hill, Second Edition, 2018.
2	Arnold S. Berger, Embedded System Design, CMP books, USA, First Edition, 2005.

REFERENCES:	
1	John B Peatman, Design with PIC Microcontrollers, Prentice Hall of India, First Edition, 2009.
2	Wayne Wolf, Computers as Components: Principles of Embedded Computing System Design, Morgan Kaufman Publishers, First Edition, 2012.
3	Steve Furber, ARM System-on-Chip Architecture, Addison-Wesley Professional, Second Edition, 2010.
4	Raj Kamal, Embedded Systems Architecture, Programming and Design, Tata McGraw-Hill, New Delhi, Third Edition, 2023.

Mapping of COs with POs and PSOs					
COs/ POs	**PO1**	**PO2**	**PO3**	**PSO1**	**PSO2**
CO1	3	1	-	1	3
CO2	3	1	-	1	3
CO3	3	1	-	1	3
CO4	3	1	-	1	3
CO5	3	1	-	1	3
Avg.	**3**	**1**	**-**	**1**	**3**
1 - Low, 2 - Medium, 3 - High					

PE24E06	**ENERGY STORAGE TECHNOLOGIES**	**Category**	**L**	**T**	**P**	**C**
		PCC	**3**	**0**	**0**	**3**

PREREQUISITE:

A strong foundation in renewable energy sources such as solar, wind, and hydroelectric power is crucial. Familiarity with Electrical Engineering Principles such as understanding power systems, circuit design, and electrical components that are integral to energy storage systems. strong analytical skills to tackle complex problems associated with energy storage technologies.

OBJECTIVES:

- To understand the fundamentals of energy storage systems.
- To know about the types and features of thermal storage systems.
- To understand about various electrical energy storage benefits.
- To know about various types of fuel cells and analysis.
- To study alternate energy storage technologies.

UNIT - I	**INTRODUCTION TO ENERGY STORAGE**	**(9)**

Emerging needs in energy storage – Characteristics of ESS – Electricity and roles of ESSs – High generation cost during peak-demand periods – Need for continuous and flexible supply – Classification of ESSs – Roles of Electrical storage technologies – Applications.

UNIT - II	**THERMAL STORAGE SYSTEM**	**(9)**

Thermal storage – Types – Modeling of thermal storage units – Simple water and rock bed storage system – Pressurized water storage system – Modelling of phase change storage system – Simple units, Packed bed storage units – Modelling using porous medium approach.

UNIT - III	**ELECTRICAL ENERGY STORAGE**	**(9)**

Fundamental concept of batteries – Measuring of battery performance, charging and discharging of a battery, storage density, energy density, and safety issues – Types of batteries: – Lead Acid, Nickel-Cadmium, Zinc-Manganese dioxide – Mathematical Modeling for Lead Acid Batteries – Flow Batteries.

UNIT - IV	**FUEL CELL**	**(9)**

Fuel Cell – History of Fuel Cell, Principles of Electrochemical Storage – Types: Hydrogen oxygen cells, Hydrogen air cell, Hydrocarbon air cell, Alkaline fuel cell – Detailed analysis – Advantages and disadvantages – Fuel Cell Thermodynamics.

UNIT – V	**ALTERNATE ENERGY STORAGE TECHNOLOGIES**	**(9)**

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
COs	**Course Outcome**	**Cognitive Level**
CO1	Describe the key characteristics that define the effective energy storage systems.	Understand
CO2	Model the different energy technologies.	Understand
CO3	Recognize the applications of various techniques.	Understand
CO4	Design and analyze the energy storage technologies.	Understand
CO5	Identify a wide variety of applications of energy storage systems for practical applications.	Understand

TEXT BOOKS:

1	James Larminie and Andrew Dicks, 'Fuel cell systems Explained', Wiley publications, 2003.
2	Lunardini. V.J, "Heat Transfer in Cold Climates", John Wiley and Sons 1981.

REFERENCES:

1	Jiujun Zhang, Lei Zhang, Hansan Liu, Andy Sun, Ru-Shi Liu, "Electrochemical technologies for energy storage and conversion", Two Volume Set, Wiley publications, 2012.
2	Schmidt. F.W. and Willmott. A.J., "Thermal Storage and Regeneration", Hemisphere Publishing Corporation, 1981.
3	Luisa F. Cabeza, "Advances in Thermal Energy Storage Systems: Methods and Applications", Woodhead Publishers, 2020.
4	Ibrahim Dinçer and Marc A. Rosen, "Thermal Energy Storage Systems and Applications", Wiley Publishers, 2021.

Mapping of COs with POs and PSOs

COs/ POs	**PO1**	**PO2**	**PO3**	**PSO1**	**PSO2**
CO1	3	-	1	1	1
CO2	3	-	1	3	3
CO3	3	-	1	2	2
CO4	3	-	1	3	3
CO5	3	-	1	3	3
Avg.	**3**	**-**	**1**	**2**	**2**

1 - Low, 2 - Medium, 3 - High

PE24E07	MODELING OF ELECTRICAL MACHINES	Category	L	T	P	C
		PCC	3	0	0	3

PREREQUISITE:

A solid basis in the fundamental concepts of circuit theory, AC and DC circuits, electromagnetic, and control systems in electrical engineering. Strong mathematical abilities are essential for evaluating power electronics, software tools, and specialized machine knowledge. These include proficiency in algebra, calculus, differential equations, and complex numbers.

OBJECTIVES:

- To acquire the knowledge of generalized theory of electrical machines.
- To investigate the concepts of reference frame theory.
- To model the electrical DC machines with voltage. Current and torque equations.
- To gain knowledge of the induction machine model in the form of a machine variable and reference variable
- To develop the synchronous machine model in the form of a machine variable and reference variable

UNIT - I	PRINCIPLES OF ELECTRO-MAGNETIC ENERGY CONVERSION	(9)

General expression of stored magnetic energy, co-energy and force/torque – Example using single and doubly excited system – Calculation of air gap MMF and per phase machine inductance using physical machine data.

UNIT - II	REFERENCE FRAME THEORY	(9)

Static and rotating reference frames – Transformation of variables – Stationary circuit variables transformed to the arbitrary reference frame – Transformation between reference frames – transformation of a balanced set – Balanced steady-state phasor and voltage equations – variables observed from several frames of reference.

UNIT - III	MODELLING OF DC MACHINES	(9)

Voltage and toque equations of DC machines – Dynamic characteristics of permanent magnet and shunt DC motors – Time domain block diagrams and State equations – Solution of dynamic characteristic by Laplace Transformation.

UNIT - IV	MODELLING OF INDUCTION MACHINES	(9)

Voltage and Torque Equation in machine variables – Equations of transformation for rotor circuits – voltage and toque equations in arbitrary reference frame variables – Analysis of steady-state operation – Free acceleration characteristics – Dynamic performance for load and torque variations – Dynamic performance during a three-phase fault – Computer simulation in the arbitrary reference frame.

UNIT - V	SYNCHRONOUS MACHINES	(9)

Voltage and Torque Equation in machine variables – Voltage and Torque Equations in arbitrary reference frame variables (Park equations) – Rotor angle and angle between rotors – Analysis of steady-state operation – Dynamic performance for torque variations- Dynamic performance during a three-phase fault – transient stability limit – Critical clearing time – computer simulation.

TOTAL = 45 PERIODS

COURSE OUTCOMES:

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

COs	Course Outcome	Cognitive Level
CO1	Understand the principles of electromechanical energy conversion.	Understand
CO2	Interpret the concepts of reference frame theory.	Evaluate
CO3	Develop the mathematical model of various DC machines using equations and find the dynamic characteristics of transformation in DC machines.	Apply
CO4	Apply the procedures to develop an Induction machine model in the form of a machine variable and reference variable.	Apply
CO5	Apply the procedures to develop a Synchronous machine model in the form of a machine variable and reference variable.	Apply

TEXT BOOKS:

1	Paul C. Krause, Oleg Wasynczuk and Scott D. Sudhoff, ‘Analysis of Electric Machinery and Drive Systems’, IEEE Press, Third Edition, 2013.
2	Stephen D Umans, ‘Fitzgerald &Kingsley’s Electric Machinery’, Seventh Edition, 2020.

REFERENCES:

1	Krishnan, R., Electric Motor Drives, Modeling, Analysis and Control, Prentice Hall of India, First Edition, Imprint, 2015.
2	Samuel Seely, Electromechanical Energy Conversion, Tata McGraw Hill Publishing Company, Second Edition, 2018.
3	Fitzgerald, A.E., Jr. Charles Kingsley, and Umanx D. Stephan, Electric Machinery, Tata McGraw Hill, Sixth Edition, 2002.
4	I J Nagrath and P Kothari, Electrical Machines, Tata McGraw Gill, Fifth Edition, 2017.

Mapping of COs with POs and PSOs

COs/ POs	PO1	PO2	PO3	PSO1	PSO2
CO1	2	2	1	-	2
CO2	3	2	1	-	2
CO3	3	2	2	-	2
CO4	3	2	2	-	2
CO5	3	2	2	-	2
Avg.	**2.8**	**2**	**1.6**	**-**	**2**

1 - Low, 2 - Medium, 3 - High

ET24E04	SYSTEM DESIGN USING MICROCONTROLLER	Category	L	T	P	C
		PCC	3	0	0	3

(Common to EST & PED)

PREREQUISITE:

Students should be familiar with memory structures, addressing modes, and instruction sets, with prior exposure to programming in Assembly and C for microcontrollers. A basic understanding of peripheral interfacing, such as ADC/DAC, Flash and EEPROM, along with experience in handling I/O ports, timers, and communication protocols like UART, is essential. Additionally, a grasp of signal generation, motor control techniques, and real-time data acquisition systems is necessary to facilitate the practical design and implementation of control systems using both PIC and ARM microcontrollers.

OBJECTIVES:

- To understand the architecture, memory organization, and addressing modes of PIC microcontrollers.
- To gain proficiency in programming PIC microcontrollers using Assembly and C languages for various embedded applications.
- To explore the utilization of I/O ports, data conversion techniques, and RAM & ROM allocation in PIC microcontroller-based systems.
- To master the implementation of timer programming for time-sensitive applications using PIC microcontrollers.
- To develop practical experience in embedded system design through hands-on practice using the MP-LAB development environment for PIC microcontrollers.

UNIT - I	PIC MICROCONTROLLER	(9)

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

UNIT - II	ARM ARCHITECTURE	(9)

Architecture – Memory organization – Addressing modes –The ARM Programmer’s model – Registers– Pipeline – Interrupts– Coprocessors – Interrupt Structure.

UNIT - III	PERIPHERALS OF PIC AND ARM MICROCONTROLLER	(9)

PIC: ADC, DAC and Sensor Interfacing –Flash and EEPROM memories. ARM: I/O Memory – EEPROM – I/O Ports – SRAM –Timer –UART – Serial Communication with PC – ADC/DAC Interfacing.

UNIT – IV	ARM MICROCONTROLLER PROGRAMMING	(9)

ARM General Instruction set – Thumb instruction set –Introduction to DSP on ARM – Implementation example of Filters.

UNIT - V	DESIGN WITH PIC AND ARM MICROCONTROLLERS	(9)

PIC implementation – Generation of Gate signals for converters and Inverters – Motor Control – Controlling DC/AC appliances – Measurement of frequency – Standalone Data Acquisition System – ARM Implementation – Simple ASM/C programs – Loops – Look up table – Block copy – subroutines – Hamming Code.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

COs	Course Outcome	Cognitive Level
CO1	Describe the basics and requirements of processor functional blocks.	Understand
CO2	Observe the specialty of RISC processor Architecture.	Apply
CO3	Incorporate I/O hardware interface of processor-based automation for consumer applications with peripherals.	Apply
CO4	Incorporate the I/O software interface of a processor with peripherals.	Apply
CO5	Elaborate the recent trends in commercial embedded processors	Apply

TEXT BOOKS:

1. Steve Furber, ‘ARM system on chip architecture’, Addison Wesley, 2010.
2. Andrew N. Sloss, Dominic Symes, Chris Wright, John Rayfield ‘ARM System Developer’s Guide Designing and Optimizing System Software’, Elsevier, 2007.

REFERENCES:

1. Muhammad Ali Mazidi, Rolin D. Mckinlay, Danny Causey ‘PIC Microcontroller and Embedded Systems using Assembly and C for PIC18’, Pearson Education, 2008.
2. John Iovine, ‘PIC Microcontroller Project Book’, McGraw Hill, 2000.
3. ARM Architecture Reference Manual, LPC213x User Manual.

Mapping of COs with POs and PSOs

COs/ POs	PO1	PO2	PO3	PSO1	PSO2
CO1	-	-	2	-	2
CO2	1	-	3	-	2
CO3	-	-	1	--	2
CO4	1	-	-	-	2
CO5	-	-	2	-	2
Avg.	**1**	**-**	**2**	**-**	**2**

1- Low, 2- Medium, 3- High

PE24E08	SPECIAL MACHINES	Category	L	T	P	C
		PCC	3	0	0	3

PREREQUISITE:

Students should acquaint themselves with the essential principles of circuits, voltage, current, power, and energy. Understanding magnetic fields, flux, inductance, and electromagnetic induction is crucial. Previous studies have focused on electric machines, including the investigation of DC machines, transformers, induction motors, and synchronous machines. Fundamental understanding of control theory and systems, as it is often applicable to the operation and control of special machines. Familiarity with power electronics is helpful, especially for understanding the drives and control techniques associated with special electrical machines.

OBJECTIVES:

- To explore the operation and types of synchronous reluctance motors.
- To explain the performance and control of stepper motors and their characteristics.
- To provide insights into the theory of operation, power converter and control of switched reluctance motor.
- To disseminate the classification, control and characteristics of permanent magnet synchronous motors.
- To describe the operation and characteristics of permanent magnet brushless DC motors.

UNIT - I	SYNCHRONOUS RELUCTANCE MOTORS	(9)

Axial flux permanent magnet machines – Comparison with radial flux machines – Principle of operation – Torque production – Axial flux switched reluctance machine – Topologies and structures – Operating principles – Output equation – Applications.

UNIT - II	STEPPER MOTORS	(9)

Constructional features – Principle of operation – Variable reluctance motor – Hybrid motor – Single and multi-stack configurations – Torque equations – Modes of excitation – Characteristics – Drive circuits – Microprocessor control of stepper motors – Closed-loop Control – Applications.

UNIT - III	SWITCHED RELUCTANCE MOTORS (SRM)	(9)

Constructional features – Rotary and Linear SRM – Principle of operation – Torque equation – Power Converters and their controllers – Methods of Rotor position sensing – Sensor less operation – Characteristics and Closed loop control – Applications.

UNIT - IV	PERMANENT MAGNET SYNCHRONOUS MOTORS	(9)

Principle of operation – EMF and Torque equations – Armature MMF – Synchronous Reactance – Sine wave motor with practical windings – Phasor diagram – Torque/speed Characteristics – Power controllers – Converter Volt-ampere requirements – Applications.

UNIT - V	PERMANENT MAGNET BRUSHLESS DC MOTORS	(9)

Commutation in DC motors – Difference between mechanical and electronic commutators – Hall sensors, Optical sensors – Multiphase Brushless motor – Square wave permanent magnet brushless motor drives – Torque and EMF equation – Power Converter Circuits and their controllers – Motor characteristics and control – Applications.

TOTAL = 45 PERIODS

COURSE OUTCOMES:

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

COs	Course Outcome	Cognitive Level
CO1	Understand the features of axial flux machines in comparison with radial flux machines and know the principles of synchronous reluctance motors.	Understand
CO2	Explain the construction and operating principles of various stepper motors.	Understand
CO3	Understand the working and various characteristics of switched reluctance machines.	Understand
CO4	Describe the construction, working principles and characteristics of permanent magnet synchronous motor and synchronous reluctance motor.	Understand
CO5	Explain the operation and performance characteristics of permanent magnet brushless DC motors.	Understand

TEXT BOOKS:

1	Miller, T.J.E., Brushless permanent magnet and reluctance motor drives, Clarendon Press, Oxford, First Edition, 1993.
2	Kenjo, T., Stepping motors and their microprocessor control, Clarendon Press, Oxford, Second Edition, 1995.

REFERENCE BOOKS:

1	Berker Bilgin, James Weisheng Jiang, Ali Emadi, Switched reluctance motor drives: fundamentals to applications, CRC Press, First Edition, 2018.
2	Krishnan, R., Electric Motor Drives – Modeling, Analysis and Control, Prentice–Hall of India Pvt. Ltd., New Delhi, First Edition, 2003.
3	Venkatrathnam, K., Special Electrical Machines, CRC Press; First Edition, 2009.
4	Bose, B.K., Modern Power Electronics and AC drives, Prentice-hall of India Pvt. Ltd, First Edition, 2008.

Mapping of COs with POs and PSOs

COs/ POs	PO1	PO2	PO3	PSO1	PSO2
CO1	3	2	3	2	2
CO2	3	2	3	2	2
CO3	3	2	3	2	2
CO4	3	2	3	2	2
CO5	3	2	3	2	2
Avg.	**3**	**2**	**3**	**2**	**2**

1- Low, 2- Medium, 3- High

PE24E09	PWM TECHNIQUES FOR POWER CONVERTERS	Category	L	T	P	C
		PCC	3	0	0	3

PREREQUISITE:

A basic knowledge in power electronics, particularly the principles of power conversion and the operation of semiconductor devices like MOSFETs and IGBTs is needed. A background in basic control theory, including feedback mechanisms and control loops, is essential for grasping modulation techniques. Knowledge of AC and DC circuits is required, along with familiarity with Pulse-Width Modulation (PWM) methods.

OBJECTIVES:

- To understand the operating principles of inverters and analyze various modulation techniques, such as sine triangle and third harmonic modulation, for optimizing performance and output filtering requirements.
- To learn the concept and application of Space Vector Modulation (SVM) in two-level inverters, focusing on the dq0 transformation and the comparison with traditional PWM techniques for harmonic reduction.
- To explore space vector modulation for three-level inverters, studying sinusoidal reference modulation, harmonic optimization, and advanced discontinuous modulation methods.
- To examine over-modulation techniques and their impact on inverter performance, including space vector approaches and harmonic elimination for optimizing inverter efficiency.
- To develop the ability to implement and optimize modulation controllers, focusing on both hardware and software elements of PWM systems for real-world inverter applications.

UNIT - I	INVERTER CONTROL STRATEGIES	(9)

Review of Inverter Operating Principle – Inverter Switching – Unipolar – Bipolar – Inverter Dead Time – Inverter Modulation – Different Types – Sine Triangle – Analysis of Sine Triangle Modulation – Trapezoidal modulation – Third harmonic modulation – Analysis of Third harmonic modulation – Comparison of Sine Triangle and Third harmonic modulation – Output filter requirement for different PWM Techniques.

UNIT - II	SPACE VECTOR MODULATION (TWO LEVEL INVERTER)	(9)

Concept of a Space vector – dq0 components of Three-phase sine wave source/level – dq0 components for voltage source Inverter operated in square wave Mode – Synchronously Rotating Reference frame – Space vector Modulation (SVM) – Principle of Space Vector Modulation – SVM Compared to regular sampled PWM – phase Leg Reference – Naturally Sampled SVM – Analytical solution – Harmonic losses – placement of the Zero space vector – Discontinuous PWM – Phase leg Reference – Analytical solution – Harmonic losses – Single edge SVM – Switched pulse sequence – Comparison of Harmonic performance.

UNIT - III	SPACE VECTOR MODULATION (THREE-LEVEL INVERTER)	(9)

Topology of a Three Phase Inverter – Three Phase Modulation with Sinusoidal reference – Third harmonic Reference injection – Analytic calculation of Harmonic Losses – Discontinuous Modulation – Triple carrier Ratio and Subharmonic Space Vector PWM – Multilevel Converter – Optimized Space Vector Sequence – Modulation for selecting switch closing state – Decomposition Methods – Hexagonal Co-ordinary System – Optimal Space Vector position within a switching period – Discontinuous Modulation in Multilevel Inverter.

UNIT - IV	**OVER MODULATION AND PROGRAMMED MODULATION OF INVERTER**	**(9)**

The over modulation Region – Naturally Sampled over modulation of one phase leg of an Inverter – Regular Sampled over modulation of one phase leg of an Inverter – Naturally Sampled over modulation of single and three phase Inverter – PWM controller gain during over modulation – Space Vector approach to over modulation – Optimized space vector Modulation – Harmonic elimination PWM – Performance index for optimality – optimum PWM – Minimum loss PWM.

UNIT - V	**IMPLEMENTATION OF MODULATION CONTROLLER**	**(9)**

Elements of a PWM converter system – VSI Power Conversion stage – Gate Drive Interface – Controller Power supply – I/O conditioning circuitry – PWM controller. Hardware Implementation of the PWM process – Analog versus digital Implementation – Digital Timer Logic Structure. PWM software Implementation – Background software – Calculation of the PWM Timing Intervals.

TOTAL = 45 PERIODS

COURSE OUTCOMES:

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

COs	Course Outcome	Cognitive Level
CO1	Describe the control strategies of inverters.	Understand
CO2	Implement the space vector modulation in two-level inverters.	Apply
CO3	Analyze the space vector modulation in three-level inverters.	Apply
CO4	Enlighten the programmed modulation of the inverter.	Understand
CO5	Implement the modulation controllers.	Understand

TEXT BOOKS:

1	Grahame Holmes, D., and Thomas A. Lipo, Pulse Width Modulation for Power Converters-Principles and Practice, IEEE Press, 2003.
2	Blaabjerg. F., Pedersen, J.K., Thoegersen, P., Improved Modulation Techniques for PWM-VSI Drive, IEEE Trans. on Industrial Electronics, vol.44, no.1, pp.87- 95, Feb.1997.

REFERENCE BOOKS:

1	Nonert, R. and Wu, R.S., Improved three-phase pulse width modulation for over modulation, IEEE Trans. on Industry Applications, Vol.1A, 20, no.5, pp.1224-1228, Sep./Oct. 1985.
2	Boys, J.T., Handley, P.G., Harmonic analysis of space vector modulated PWM waveforms, IEEE Proceedings (London), vol. 137, no.4, pp. 197-204, July 1990.
3	Celanovic, N., Boroyevich, D., Comprehensive study of neutral-point voltage balancing problem in three-phase converters, IEEE Trans. on Industry Application, vol.37, no.2, pp.637-641, 2001.

Mapping of COs with POs and PSOs

COs/ POs	PO1	PO2	PO3	PSO1	PSO2
CO1	3	2	2	2	2
CO2	3	2	2	2	2
CO3	3	2	2	2	2
CO4	3	2	2	2	2
CO5	3	2	2	2	2
Avg.	**3**	**2**	**2**	**2**	**2**

1- Low, 2- Medium, 3- High

PE24E10	POWER QUALITY MANAGEMENT	Category	L	T	P	C
		PCC	3	0	0	3

PREREQUISITE:

Students should be familiar with a basic understanding of electrical systems and common power issues like voltage fluctuations and harmonics. Familiarity with fundamental measurement tools such as multimeters and power analyzers is important for identifying problems. Knowledge of basic power quality improvement techniques, including proper grounding and filtering, is essential.

OBJECTIVES:

- To impart comprehensive knowledge of fundamental concepts underlying diverse power quality issues and their implications in electrical systems
- To understand and mitigate the impacts of various Non-Linear loads and issues.
- To equip students with the fundamentals in analyzing electrical system parameters to identify, quantify, and address power quality issues
- To evaluate power quality disturbances and implement traditional solutions for improving electrical system performance and reliability.
- To enhance the stability and efficiency of electrical systems by mitigating disturbances and ensuring consistent power quality.

UNIT - I	INTRODUCTION	(9)

Characterization of Electric Power Quality: Transients, short duration and long duration voltage variations, Voltage imbalance, waveform distortion, Voltage fluctuations, Power frequency variation, Power acceptability curves – power quality problems: poor load power factor, Non-linear and unbalanced loads, DC offset in loads, Notching in load voltage, Disturbance in supply voltage – Power quality standards.

UNIT - II	NON- LINEAR LOADS	(9)

Single phase and Three phase AC-DC converters, Battery chargers, Arc furnaces, Fluorescent lighting, SMPS devices, Adjustable speed drives.

UNIT - III	POWER QUALITY MONITORING	(9)

Monitoring and diagnostic techniques for various power quality problems – modeling of power quality (harmonics and voltage sag) problems by mathematical simulation tools – power line disturbance analyzer – quality measurement equipment – harmonic/spectrum analyzer – flicker meters – disturbance analyzer. Applications of expert systems for power quality monitoring.

UNIT - IV	ANALYSIS AND CONVENTIONAL MITIGATION METHODS	(9)

Analysis of power outages, Analysis of unbalance: Symmetrical components of 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 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.

UNIT - V	POWER QUALITY IMPROVEMENT	(9)

Utility-Customer interface – Harmonic filters: passive, Active and hybrid filters – Custom power devices: Network reconfiguring Devices, Load compensation using DSTATCOM, Voltage regulation using DSTATCOM, protecting sensitive loads using DVR, UPQC – control strategies: P-Q theory, Synchronous detection method – Custom power park – Status of application of custom power devices.

TOTAL = 45 PERIODS

COURSE OUTCOMES:

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

COs	Course Outcome	Cognitive Level
CO1	Summarize the various Power quality issues.	Remember
CO2	Identify the various Non-Linear loads and issues.	Apply
CO3	Explain the monitoring and diagnostic techniques for power quality issues.	Remember
CO4	Analyze the Mitigation methods for power quality issues.	Understand
CO5	Describe the various power quality improvement methods.	Remember

TEXT BOOKS:

1	Roger. C. Dugan, Mark. F. McGranagham, Surya Santosoamd H.Wayne Beaty, ‘Electrical Power Systems Quality’, McGraw Hill, Second Edition, 2003.
2	Arindam Ghosh, ‘Power Quality Enhancement Using Custom Power Devices’, Kluwer Academic Publishers, First Edition, 2011.

REFERENCES:

1	Heydt, G.T., ‘Electric Power Quality’, Stars in Circle Publications, Second Edition, 1994.
2	Duggan, R.C., ‘Power Quality’, IEEE Press Series on Power, Third Edition, 2010.
3	Arrillaga, J., Watson, N.R., ‘Power system harmonics’, Wiley Publication, Second Edition, 2012.
4	Derek A. Paice, ‘Power electronic converter harmonics’, IEEE Press, Second Edition, 2012.

Mapping of COs with POs and PSOs

COs/ POs	PO1	PO2	PO3	PSO1	PSO2
CO1	3	2	-	3	2
CO2	3	2	-	3	2
CO3	3	2	1	3	2
CO4	3	2	1	3	2
CO5	3	2	1	3	2
Avg.	**3**	**2**	**1**	**3**	**2**

1- Low, 2- Medium, 3- High

<table>
<tr><td rowspan="2">PE24E11</td><td rowspan="2">SYSTEM THEORY</td><td>Category</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>PCC</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
</table>

PREREQUISITE:

Sound skill in basic mathematics like Algebra, Calculus, Linear Algebra. Basic statistical concepts are important for analyzing data and understanding system performance. Probability theory helps in modeling and predicting system behaviors under uncertainty. Engineering fundamentals like Control Systems and Signal Processing are crucial for signal processing and analysis in the system. Basic logic and set theory provide a foundation for understanding formal systems and their properties.

OBJECTIVES:

- To educate on modeling and representing systems in state variable form
- To train on solving linear and non-linear state equations
- To gain knowledge about time variant and invariant case controllability and observability
- To classify non–linearities and examine stability analysis of systems in the sense of Lyapunov's theory.
- To develop ability on modal concepts, design of state, output feedback controllers and estimators.

UNIT - I	**STATE VARIABLE REPRESENTATION**	**(9)**

Limitations of classical control theory – Concepts of state, state variables and state model – State model for linear time-invariant systems: State-space representation using physical, phase and canonical variables - Transfer function from state model – State variable formulation of SISO systems: Buck and boost converter and MIMO systems – Non-uniqueness of state model.

UNIT - II	**SOLUTION OF STATE EQUATION**	**(9)**

Existence and uniqueness of solutions to Continuous-time state equations – Solution of Non-Linear and Linear time-varying state equations – Evaluation of matrix exponential – System modes – Role of Eigen values and Eigen vectors.

UNIT - III	**CONTROLLABILITY AND OBSERVABILITY**	**(9)**

Definitions - Kalman's and Gilbert's tests - Controllable and observable phase variable forms - Effect of pole-zero cancellation on controllability and observability – Test for continuous-time systems: Time variant and Invariant case – Output controllability.

UNIT - IV	**STABILTY ANALYSIS**	**(9)**

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

UNIT - V	**MODAL ANALYSIS**	**(9)**

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

TOTAL = 45 PERIODS

COURSE OUTCOMES:

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

COs	Course Outcome	Cognitive Level
CO1	Model the physical systems in terms of mathematical models for easier analysis.	Apply
CO2	Provide solutions to state equations using different techniques.	Apply
CO3	Analyze the system's controllability and observability.	Analyze
CO4	Analyze the stability of the system using the Lyapunov theory.	Analyze
CO5	Perform Modal analysis of controller and observer in a state space form.	Analyze

TEXT BOOKS:

1	Gopal, M., ‘Modern Control System Theory’, New Age International, Fourth Edition, 2005.
2	Katsuhiko Ogata, Modern Control Engineering, Pearson, New Delhi, Fifth Edition, 2009.

REFERENCES:

1	Gopal M, ‘Digital Control and State Variable Methods’, McGraw-Hill Publishing Company Limited, New Delhi, India, Fourth Edition, 2017.
2	Benjamin C Kuo, ‘Automatic Control Systems’, John Wiley & Sons, Inc., Delhi, Ninth Edition, 2014.
3	Bubnicki, Z., ‘Modern Control Theory’, Springer, First Edition, 2005.
4	Norman S Nise, ‘Nise’s Control Systems Engineering’, John Wiley & Sons, Inc, Delhi, First Edition, 2018.

Mapping of COs with POs and PSOs

COs/ POs	PO1	PO2	PO3	PSO1	PSO2
CO1	3	2	2	3	2
CO2	3	2	2	3	2
CO3	3	2	2	3	2
CO4	3	2	2	3	2
CO5	3	2	2	3	2
Avg.	**3**	**2**	**2**	**3**	**2**

1- Low, 2- Medium, 3- High

<table>
<tr><td rowspan="2">PE24E12</td><td rowspan="2">INDUSTRIAL ROBOTICS</td><td>Category</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>PCC</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
</table>

PREREQUISITE:

Students should have a basic knowledge of mechanics, kinematics, dynamics, and materials science, which are essential for understanding the physical structure and movement of robots. Knowledge of control theory, including feedback systems, PID controllers, and stability analysis, is crucial for understanding how robots are controlled. Familiarity with electrical circuits, sensors, actuators, and signal processing, as these components are integral to robot operation.

OBJECTIVES:

- To understand and articulate the fundamental principles of robot technology, including the underlying physical laws, mechanical structures, and various robot configurations.
- To equip students with the knowledge and skills to study and illustrate different robotic drive systems, power sources, and sensor technologies.
- To disseminate the design concepts and configurations of robotic manipulators, grippers, and end effector mechanisms and their functions in robotic systems.
- To provide a foundational understanding of robot kinematics, familiarize them with relevant programming languages, and introduce key concepts of path planning and robotic motion strategies.
- To expose students to several robotics applications in manufacturing and non-manufacturing industries and investigate AI technology that might improve robotic capabilities.

UNIT - I	**INTRODUCTION TO ROBOTICS**	**(9)**

Robotics and Automation – Introduction to Robotics, Definition and Origin of Robotics – Historical Development – Asimov's Laws of Robotics – Complete Classification of Robots – Fundamentals about Robot Technology – Degrees of Freedom – Configurations and their Relative Merits and Demerits – Dynamic Stabilization of Robotics – Industrial applications of robot.

UNIT - II	**POWER SOURCES AND SENSORS**	**(9)**

Types of Drive Systems – Hydraulic, Pneumatic and Electric Drives Block Diagram Approach – Determination of HP of Motor and Gearing Ratio – Variable Speed Arrangements – Path Determination – Micro Machines in Robotics – Machine Vision – Ranging, Laser, Acoustic, Magnetic, Fiber Optic, Tactile and Intelligent Sensors Definition and Use.

UNIT - III	**MANIPULATORS AND GRIPPERS**	**(9)**

General Description of Robot Manipulator – Construction of Manipulators – Manipulator Motions – Manipulator Dynamics and Force Control – Electronics and Pneumatic Manipulator Control Circuits – End Effectors – Mechanism of Gripping – U Various Types of Grippers – Design Considerations.

UNIT - IV	**KINEMATICS AND PATH PLANNING**	**(9)**

Robot kinematics – Kinematic Equations, Forward and Inverse Kinematics – Solution of Inverse Kinematics Problem – Multiple Solution Jacobian Work Envelope – Hill Climbing Techniques – Robot Programming Languages.

UNIT - V	**APPLICATIONS**	**(9)**

Selection of Robot – Robot Applications in Industry – Design a Modern Robot for Manufacturing and Non-Manufacturing Industry – Robot Cell Design – Introduction to Artificial Intelligence (AI) – AI techniques, Need and application of AI – New trends and recent updates in robotics.

TOTAL = 45 PERIODS

COURSE OUTCOMES:

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

COs	Course Outcome	Cognitive Level
CO1	Explain the robot technology as their fundamental principles, laws and robot configurations.	Understand
CO2	Illustrate the various drive systems, power sources and the concepts of sensors to control the robots.	Understand
CO3	Outline the design configurations of manipulators, grippers and end effector mechanisms in robots.	Understand
CO4	Outline the robot kinematics, programming language and the concepts of path planning for robotics.	Understand
CO5	Describe the wide range of robotic applications of manufacturing and non-manufacturing sectors and AI technology in robotics.	Understand

TEXT BOOKS:

1	Mikell P. Groover, Weiss G.M., Nagel R.N., Odraj N.G., ‘Industrial Robotics’, McGraw Hill Singapore, First Edition, 1996.
2	Saha, S.K., Introduction to Robotics, TATA McGraw Hills Education, Second Edition, 2014.

REFERENCE BOOKS:

1	Asitava Ghoshal, Robotics: Fundamental concepts and analysis, Oxford University Press, First Edition, 2006.
2	Deb S.R., Robotics Technology and Flexible Automation, John Wiley, USA, Second Edition, 2010.
3	Klafter R.D., Chimielewski T.A., Negin M., Robotic Engineering - An Integrated Approach, Prentice Hall of India, New Delhi, First Edition, 1994.
4	Niku, S.B., Introduction to Robotics: Analysis, Control, Applications, John Wiley & Sons Ltd., Third Edition, 2019.

Mapping of COs with POs and PSOs

COs/ POs	PO1	PO2	PO3	PSO1	PSO2
CO1	3	2	3	2	2
CO2	3	2	3	2	2
CO3	3	2	3	2	2
CO4	3	2	3	2	2
CO5	3	2	3	2	2
Avg.	**3**	**2**	**3**	**2**	**2**

1- Low, 2- Medium, 3- High

PE24E13	ADVANCED DIGITAL SIGNAL PROCESSING	Category	L	T	P	C
		PCC	3	0	0	3

PREREQUISITE:

To effectively grasp the topics covered in this syllabus, students should have a foundational understanding of key concepts in probability, random processes, and digital signal processing (DSP). A background in basic probability and statistics is essential for understanding discrete random processes, ensemble averages, and correlation functions. Familiarity with signals and systems, including the analysis of both continuous and discrete-time signals, Fourier transforms, and filter design, is crucial for understanding spectral estimation and filtering techniques. Additionally, knowledge of linear algebra, particularly in solving linear equations and working with matrices, is necessary for topics such as linear prediction and adaptive filtering.

OBJECTIVES:

- To provide with a solid foundation in the theory and application of discrete random processes, including stationary processes, correlation, and ergodic properties, enabling them to interpret random signals in various contexts.
- To introduce the various spectrum estimation methods, including traditional techniques and advanced models such as AR, MA, and ARMA, equipping them with the tools needed to accurately estimate the power spectrum of discrete signals.
- To impart the principles and applications of linear prediction, including forward and backward prediction methods and the implementation of Wiener filters for signal prediction and filtering.
- To familiarize with the concepts and applications of adaptive filtering, focusing on algorithms such as the LMS and RLS, and their use in real-world applications like noise cancellation, echo cancellation, and channel equalization.
- To understand the mathematical and practical aspects of multirate digital signal processing, including sampling rate conversion, interpolation, decimation, and the design of efficient filter structures for various digital signal processing applications.

UNIT - I	DISCRETE RANDOM SIGNAL PROCESSING	(9)

Discrete random process – stationary process – ensemble averages – auto correlation – auto covariance matrices – mean ergodic process and correlation – ergodic process – Parseval's theorem – Wiener Khin chine relation – power density spectrum – low pass and high pass filters.

UNIT - II	SPECTRUM ESTIMATION AND ANALYSIS	(9)

Principles – Traditional methods: pitfalls, windowing, periodogram, modified periodogram, Blackman – Tukey method – fast correlation method – AR model – Yule-Walker method – Burg method – MA model – ARMA model.

UNIT - III	LINEAR PREDICTION	(9)

Forward and backward predictions – Solution of the normal equations – Levinson – Durbin Algorithms – Least mean squared error criterion – FIR Wiener filter and Wiener IIR filters – Wiener filter for filtering and prediction.

UNIT - IV	ADAPTIVE FILTER	(9)

Concepts of adaptive filter – FIR adaptive filters – Newton's steepest descent method – Adaptive filter based on steepest descent method – Widrow Hoff LMS adaptive algorithm – Adaptive channel equalization – Adaptive echo chancellor – Adaptive noise cancellation – RLS Adaptive filters – Exponentially weighted RLS – Sliding window RLS – Simplified HR LMS adaptive filter.

UNIT - V	MULTIRATE DIGITAL SIGNAL PROCESSING	(9)
Mathematical description of sampling rate – Interpolation and Decimation by integer factor – Sampling rate conversion by rational factor – Filter design for sampling rate conversion: direct form FIR structures, Polyphase structures, time-variant structures – Multistage implementation of multirate system – Applications – High-quality analog to digital conversion for digital audio, efficient implementation of narrowband digital filters.		
		TOTAL = 45 PERIODS

COURSE OUTCOMES:

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

COs	Course Outcome	Cognitive Level
CO1	Characterize discrete random processes using statistical measures such as autocorrelation, autocovariance, and power density spectrum, applying these concepts to practical signal processing problems.	Understand
CO2	Evaluating various spectrum estimation methods, including periodograms and model-based approaches, to accurately determine the spectral content of signals in different scenarios.	Apply
CO3	Solve linear prediction models using algorithms like Levinson-Durbin, applying these techniques to filter and predict discrete-time signals effectively.	Apply
CO4	Design adaptive filters using algorithms such as LMS and RLS, applying these filters to solve complex problems in adaptive noise cancellation, echo suppression, and signal equalization.	Apply
CO5	Implement multi-rate digital signal processing systems, including sampling rate converters and polyphase filter structures, and apply these systems to improve digital audio processing and narrowband filter design.	Apply

TEXT BOOKS

1	Monson H. Hayes, Statistical Digital Signal Processing and Modeling, Wiley India Pvt. Limited, Second Edition, 2009.
2	John G. Proakis, Dimitris G.Manolakis, Digital Signal Processing: Principles Algorithms and Applications, Pearson Education India, Fourth Edition, 2014.

REFERENCES BOOKS:

3	Emmanuel C. Ifeachor, Barrie N. Jervis, Digital Signal Processing - A Practical Approach, Addison – Wesley publishing company, Second Edition, 2002.
4	Sanjit Kumar Mitra., Digital Signal Processing - A computer-based approach, Tata McGraw Hill, New Delhi, Fourth Edition, 2011.
5	Saeed V. Vaseghi, Advanced Signal Processing and Digital Noise Reduction, Wiley Teubner, 2013.

Mapping of COs with POs and PSOs

COs/ POs	PO1	PO2	PO3	PSO1	PSO2
CO1	3	-	2	2	3
CO2	3	-	2	2	3
CO3	3	-	2	2	3
CO4	3	-	2	2	3
CO5	3	-	2	2	3
Avg.	**3**	**-**	**2**	**2**	**3**

1- Low, 2- Medium, 3- High

PE24E14	POWER ELECTRONICS IN WIND AND SOLAR POWER CONVERSION	Category	L	T	P	C
		PCC	3	0	0	3

PREREQUISITE:

A solid grasp of power electronics is vital for converting renewable energy sources into usable electrical energy. Knowledge of electrical machines is important as they are often integral to renewable energy systems. Knowledge about photovoltaic cells, modules, arrays, and system configurations including grid-tied vs. off-grid systems.

OBJECTIVES:

- To analyze the trends in global energy consumption and focusing on the availability of conventional and renewable energy sources.
- To understand the fundamental principles and characteristics of solar energy.
- To develop a robust solar photovoltaic system that maximizes efficiency, reliability, and adaptability
- To analyze and synthesize the operational principles, performance characteristics, and control strategies of wind energy.
- To understand the both stand-alone operations and grid integration strategies for different types of wind energy conversion technologies

UNIT - I	ENERGY SOURCES	(9)

Trends in energy consumption – World energy scenario – Energy sources and their availability – Conventional and renewable sources – Emerging energy technologies – Solar potential in India –Solar cells and their characteristics – Nature of Wind – Wind survey in India – Power in the wind – Maximum Power Point Tracking (MPPT).

UNIT - II	SOLAR PHOTOVOLTAICS	(9)

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

UNIT - III	PHOTOVOLTAIC SYSTEM DESIGN	(9)

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

UNIT - IV	WIND ENERGY CONVERSION	(9)

Review of reference theory fundamentals – principle of operation and analysis of IG, PMSG, SCIG and DFIG, Power Converters – Three Phase AC voltage controllers – AC-DC-AC converters, Cyclo converter – PWM Inverters, Grid Interactive Inverters – Matrix Converters.

UNIT – V	ANALYSIS OF WIND SYSTEMS	(9)

Stand-alone operation of fixed and variable speed wind energy conversion systems – Grid connection Issues – Grid integrated PMSG and SCIG Based WECS.

TOTAL = 45 PERIODS

COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
COs	**Course Outcome**	**Cognitive Level**
CO1	Describe the various energy sources, energy policies and environmental aspects of energy.	Remember
CO2	Develop a stand-alone photo voltaic system and implement maximum power point tracking in the PV system.	Remember
CO3	Design a stand-alone and Grid-connected PV system.	Understand
CO4	Explain the operation of the wind energy conversion system with different converters.	Remember
CO5	Analyze the wind system with different wind energy conversion systems.	Understand

TEXT BOOKS:	
1	S.N. Bhadra, D. Kastha, S. Banerjee ‘Wind Electrical Systems’, Oxford University Press, 2009.
2	Rashid, M.H., ‘Power Electronics Handbook’, Academic Press, Fourth Edition, 2017.

REFERENCES:	
1	Rai. G.D, ‘Solar energy utilization’, Khanna publishes 1993.
2	Chetan Singh Solanki, ‘Solar Photovoltaics: Fundamentals, Technologies and Applications’, PHI Learning Private Limited, 2012.
3	John Twideu and Tony Weir, ‘Renewal Energy Resources’, BSP Publications, 2006.
4	B.H.Khan, ‘Non-conventional Energy sources’, McGraw-Hill, Second Edition, 2009.

Mapping of COs with POs and PSOs

COs/ POs	**PO1**	**PO2**	**PO3**	**PSO1**	**PSO2**
CO1	3	-	-	1	1
CO2	3	-	-	2	2
CO3	3	-	-	3	3
CO4	3	-	-	2	2
CO5	3	-	-	3	3
Avg.	**3**	**-**	**-**	**2.2**	**2.2**

1- Low, 2- Medium, 3- High

PE24E15	ELECTRIC VEHICLES	Category	L	T	P	C
		PEC	3	0	0	3

PREREQUISITE:

Strong foundation in basic automotive knowledge and electrical circuits and components. Familiarity with the types of batteries used in hybrids, such as lithium-ion and nickel-metal hydride, and their operation. Basic understanding of control systems and algorithms used in managing hybrid power trains.

OBJECTIVES:

- To understand the basic concepts of hybrid vehicles and vehicle dynamics.
- To explain plug-in hybrid vehicle architecture, design and component sizing and the drive train topologies used in hybrid vehicles.
- To examine various electric drives suitable for hybrid electric vehicles.
- To understand the electric propulsion unit used in hybrid vehicles.
- To discuss different energy storage technologies used for hybrid vehicles and their power management.

UNIT - I	HYBRID ELECTRIC VEHICLES	(9)

Impact of different transportation technologies on environment and energy supply – Air pollution and global warming – History of hybrid electric and fuel cell vehicles – Vehicle motion – Dynamic equations for the vehicle – vehicle power plant and transmission characteristics – Fuel economy characteristics of internal combustion engine.

UNIT - II	HYBRID POWER TRAIN TOPOLOGY AND DYNAMICS	(9)

Basic architecture – Analysis of drive trains and power flows – Drive cycle implications and fuel efficiency estimations – Sizing of components for different hybrid drive train topologies – Topologies for electric drive train – Fuel efficiency estimations and wheel-to-wheel fuel efficiency analysis – Sizing of components for different electric drive-train topologies.

UNIT - III	ELECTRIC PROPULSION UNIT	(9)

Electric drives used in HEV/EVs – Classifications and characteristics – DC motor drives – Induction motor drives – Permanent magnet BLDC motor drives – Switched Reluctance Motor (SRM) drives – Losses in traction motors, inverters and efficiency maps.

UNIT - IV	SIZING OF DRIVES	(9)

Sizing the power electronics based on switch technology – Switching frequency and ripple capacitor design – Selection of energy storage technology – Matching the electric drive and ICE – Transmission selection and gear step selection – Sizing the propulsion motor.

UNIT - V	VEHICLE POWER MANAGEMENT AND ENERGY STORAGE SYSTEMS	(9)

Energy storage, battery-based energy storage and simplified models of battery – Fuel cells – Super capacitor – Flywheels and their modeling for energy storage in EHV/BEV – Energy management strategies and its general architecture – Rule and optimization-based energy management strategies.

TOTAL = 45 PERIODS

COURSE OUTCOMES:

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

COs	Course Outcome	Cognitive Level
CO1	Elucidate the hybrid electric vehicles and their characteristics.	Understand
CO2	Illustrate the different hybrid power train topology and fuel efficiency analysis.	Understand
CO3	Enlighten the electric propulsion system and the drive motor control system.	Understand
CO4	Explain the selection of energy storage technology and the sizing of drives.	Understand
CO5	Describe the energy management strategies and energy storage systems.	Understand

TEXT BOOKS:

1	Iqbal Hussein, 'Electric and Hybrid Vehicles: Design Fundamentals', CRC Press, Second Edition, 2021.
2	Mehrdad Ehsani, Yimin Gao, Sebatien Gay and Ali Emadi, 'Modern Electric, Hybrid Electric, and Fuel cell vehicles: Fundamentals, Theory and Design', CRC Press, First Edition, 2009.

REFERENCES:

1	James Larminie and John Lowry, 'Electric Vehicle Technology Explained', John Wiley & Sons Ltd, Second Edition, 2012.
2	Sandeep Dhameja, 'Electric Vehicle Battery Systems', Butterworth – Heinemann, First Edition, 2015.
3	Ronald K Jurgen, 'Electric and Hybrid-Electric Vehicles', SAE, First Edition, 2011.
4	Ron Hodkinson and John Fenton, 'Light Weight Electric/Hybrid Vehicle Design', Butterworth-Heinemann, First Edition, 2009.

Mapping of COs with POs and PSOs

COs/ POs	PO1	PO2	PO3	PSO1	PSO2
CO1	2	-	2	3	2
CO2	3	-	2	3	2
CO3	2	-	2	3	2
CO4	2	-	2	2	2
CO5	3	-	2	3	3
Avg.	**2.4**	**-**	**2**	**2.8**	**2.2**

1- Low, 2- Medium, 3- High