DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
ANNA UNIVERSITY, CHENNAI – 25

VISION:

The vision of the department is to produce analytically proficient and technologically competent Electrical and Electronics Engineers who can serve and take forward the academic, industry and research organizations to newer heights and be effective for building the nation.

MISSION:

- To impart high quality technical education with the state of the art laboratory practice.
- To provide conducive academic ambience to enable best teaching and learning processes.
- To generate resources through research and consultancy projects for pursuing research and developmental activities in emerging areas.
- To associate with academic and industrial organizations for research activities to develop and provide vital and viable solutions for social needs indigenously.
- To develop leadership skills in students with high degree of ethics, morals and values and instill confidence to lead the organization.

ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
REGULATIONS -2023
CHOICE BASED CREDIT SYSTEM
M.E. POWER SYSTEMS ENGINEERING
CURRICULUM AND SYLLABUS I TO IV SEMESTERS

1. PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

I.	Get elevated as technically competent Power Engineer to cater the needs of Electrical Power Industry, Research and Educational Institutions
II.	Become an entrepreneur in modern restructured power systems, proficient in application software packages used in the Power System industry.
III.	Pursue career in core service sector of power system industry with life long learning and professional ethics.

2. PROGRAMME OUTCOMES (POs)

On successful completion of the programme, the graduate would have	
PO1	An ability to independently carry out the research/investigation and development work to solve practical problems .
PO2	An ability to write and present a substantial technical report/document.
PO3	An ability to demonstrate mastery in power system engineering for reliable and secure operation of power grid.
PO4	To model and analyze power system components and perform steady state and dynamics analysis.
PO5	To develop adaptive protection schemes with renewable energy penetration in the grid.
PO6	To design controllers for damping enhancement and mitigation of oscillations in power systems.

3. MAPPING OF PEOs with POs

PROGRAMME EDUCATIONAL OBJECTIVES	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
I	3	1	2	2	3	3
II	3	2	3	3	2	3
III	3	2	3	2	3	3

Mapped with 1,2,3 &- scale :1-low ; 2-medium ; 3-high ; ‘ - ’ no correlation.

Attested

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PROGRAM ARTICULATION MATRIX

		COURSE NAME	PO1	PO2	PO3	PSO1	PSO2	PSO3
YEAR I	SEM I	Research Methodology and IPR						
		Computer Aided Power System Analysis	3	2	1.8	2	1.2	1.6
		Analysis and Computation of Electromagnetic Transients In Power Systems	2.6	1.25	2.8	2.4	3	3
		Industrial Power System Analysis and Design	1	2	2	1	1.66	1.5
		HVDC and FACTS	2.6	1.5	3	2.4	2	3
		Professional Elective - I						
		Power System Laboratory	1	2	1.33	1.8	2	1.25
		HVDC and FACTS Laboratory	2	1.4	3	2.4	2	3
	SEM !!	Advanced Power System Protection	1.8	2.4	2.4	2.6	2.2	1.4
		Restructured Power System	3	1	2	3	-	-
		Smart Grid	1	2	2	1	1.33	1.67
		Power System Dynamics	3	1	3	2.4	2	3
		Professional Elective II						
		Professional Elective III						
		Power System Protection Laboratory	2.4	2.6	3	2.4	2	3
		Power System Micro Grid Laboratory	3	3	3	1	-	-
YEAR II	SEM III	Professional Elective IV						
		Professional Elective V						
		Professional Elective VI						
		Project Work I						
	SEM IV	Project Work II						

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ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
REGULATIONS -2023
CHOICE BASED CREDIT SYSTEM
M.E.POWER SYSTEMS ENGINEERING (FULL TIME)
CURRICULUM AND SYLLABUS I TO IV SEMESTERS

SEMESTER I

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	RM3151	Research Methodology and IPR	RMC	2	1	0	3	3
2.	PS3101	Computer Aided Power System Analysis	FC	3	0	0	3	3
3.	PS3151	Analysis and Computation of Electromagnetic Transients in Power Systems	PCC	3	0	0	3	3
4.	PS3102	Industrial Power System Analysis and Design	PCC	3	0	0	3	3
5.	PS3152	HVDC and FACTS	PCC	3	0	0	3	3
6.		Professional Elective I	PEC	3	0	0	3	3
PRACTICAL								
7.	PS3111	Power System Laboratory	PCC	0	0	4	4	2
8.	PS3112	HVDC and FACTS Laboratory	PCC	0	0	4	4	2
			TOTAL	**17**	**1**	**8**	**26**	**22**

SEMESTER II

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	PS3201	Advanced Power System Protection	PCC	3	0	0	3	3
2.	PS3251	Restructured Power System	PCC	3	0	0	3	3
3.	PS3252	Smart Grid	PCC	3	0	0	3	3
4.	PS3202	Power System Dynamics	PCC	3	0	0	3	3
5.		Professional Elective II	PEC	3	0	0	3	3
6.		Professional Elective III	PEC	3	0	0	3	3
PRACTICALS								
7.	PS3211	Power System Protection Laboratory	PCC	0	0	4	4	2
8.	PS3212	Power System Micro Grid Laboratory	PCC	0	0	4	4	2
			TOTAL	**18**	**0**	**8**	**26**	**22**

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SEMESTER III

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK L	T	P	TOTAL CONTACT PERIODS	CREDITS
THEORY								
1.		Professional Elective IV	PEC	3	0	0	3	3
2.		Professional Elective V	PEC	3	0	0	3	3
3.		Professional Elective VI	PEC	3	0	0	3	3
PRACTICALS								
4.	PS3311	Project Work I	EEC	0	0	12	12	6
			TOTAL	**9**	**0**	**12**	**21**	**15**

SEMESTER IV

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK L	T	P	TOTAL CONTACT PERIODS	CREDITS
PRACTICALS								
1.	PS3411	Project Work II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL CREDITS : 71

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ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
REGULATIONS -2023
CHOICE BASED CREDIT SYSTEM
M.E.POWER SYSTEMS ENGINEERING (PART TIME)
I TO VI SEMESTERS CURRICULA & SYLLABI

SEMESTER I

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK L	T	P	TOTAL CONTACT PERIODS	CREDITS
THEORY								
1.	RM3151	Research Methodology and IPR	RMC	2	1	0	3	3
2.	PS3101	Computer Aided Power System Analysis	FC	3	0	0	3	3
3.	PS3151	Analysis and Computation of Electromagnetic Transients in Power Systems	PCC	3	0	0	3	3
PRACTICAL								
4.	PS3111	Power System Laboratory	PCC	0	0	4	4	2
			TOTAL	**8**	**1**	**4**	**13**	**11**

SEMESTER II

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK L	T	P	TOTAL CONTACT PERIODS	CREDITS
THEORY								
1.	PS3201	Advanced Power System Protection	PCC	3	0	0	3	3
2.	PS3251	Restructured Power System	PCC	3	0	0	3	3
3.	PS3252	Smart Grid	PCC	3	0	0	3	3
PRACTICALS								
4.	PS3211	Power System Protection Laboratory	PCC	0	0	4	4	2
			TOTAL	**9**	**0**	**4**	**13**	**11**

SEMESTER III

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK L	T	P	TOTAL CONTACT PERIODS	CREDITS
THEORY								
1	PS3102	Industrial Power System Analysis and Design	PCC	3	0	0	3	3
2	PS3152	HVDC and FACTS	PCC	3	0	0	3	3
3		Professional Elective I	PEC	3	0	0	3	3
PRACTICAL								
4	PS3112	HVDC and FACTS Laboratory	PCC	0	0	4	4	2
			TOTAL	**9**	**0**	**4**	**13**	**11**

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SEMESTER IV

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1	PS3202	Power System Dynamics	PCC	3	0	0	3	3
2		Professional Elective II	PEC	3	0	0	3	3
3		Professional Elective III	PEC	3	0	0	3	3
PRACTICALS								
4	PS3212	Power System Micro Grid Laboratory	PCC	0	0	4	4	2
			TOTAL	**9**	**0**	**4**	**13**	**11**

SEMESTER V

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.		Professional Elective IV	PEC	3	0	0	3	3
2.		Professional Elective V	PEC	3	0	0	3	3
3.		Professional Elective VI	PEC	3	0	0	3	3
PRACTICALS								
4.	PS3311	Project Work I	EEC	0	0	12	12	6
			TOTAL	**9**	**0**	**12**	**21**	**15**

SEMESTER VI

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	PS3411	Project Work II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL CREDITS : 71

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FOUNDATION COURSES (FC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK L	T	P	CREDITS	SEMESTER
1.	PS3101	Computer Aided Power System Analysis	3	0	0	3	1

RESEARCH METHODOLOGY AND IPR COURSES (RMC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK L	T	P	CREDITS	SEMESTER
1.	RM3151	Research Methodology and IPR	2	1	0	3	1
					TOTAL CREDITS	**3**	

PROFESSIONAL CORE COURSES (PCC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK L	T	P	CREDITS	SEMESTER
1.	PS3151	Analysis and Computation of Electromagnetic Transients in Power Systems	3	0	0	3	1
2.	PS3102	Industrial Power System Analysis and Design	3	0	0	3	1
3.	PS3152	HVDC and FACTS	3	0	0	3	1
4.	PS3111	Power System Laboratory	0	0	4	2	1
5.	PS3112	HVDC and FACTS Laboratory	0	0	4	2	1
6.	PS3201	Advanced Power System Protection	3	0	0	3	2
7.	PS3251	Restructured Power System	3	0	0	3	2
8.	PS3252	Smart Grid	3	0	0	3	2
9.	PS3202	Power System Dynamics	3	0	0	3	2
10.	PS3211	Power System Protection Laboratory	0	0	4	2	2
11.	PS3212	Power System Micro Grid Laboratory	0	0	4	2	2
					TOTAL CREDITS	**29**	

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PROFESSIONAL ELECTIVE COURSES (PEC)

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1	PS3001	Power System State Estimation and Security Assessment	PEC	3	0	0	3	3
2	PS3002	Computer Relaying and Wide Area Measurement Systems	PEC	3	0	0	3	3
3	PS3053	Optimization Techniques to Power System Engineering	PEC	3	0	0	3	3
4	PS3054	Wind Energy Conversion Systems	PEC	3	0	0	3	3
5	PS3052	Distributed Generation and Micro Grid	PEC	3	0	0	3	3
6	PS3051	Computational Intelligence Techniques to Power Systems	PEC	3	0	0	3	3
7	PS3003	Power System Planning and Reliability	PEC	3	0	0	3	3
8	PW3251	Energy Storage Systems	PEC	3	0	0	3	3
9	PW3052	Electric Vehicles and Power Management	PEC	3	0	0	3	3
10	PW3057	Renewable Energy Technology	PEC	3	0	0	3	3
11	PW3152	Energy Conservation and Sustainable Development	PEC	3	0	0	3	3
12	PE3151	Analysis of Power Converters	PEC	3	0	0	3	3
13	PE3053	Power Quality	PEC	3	0	0	3	3
14	HV3151	Electrical Transients in Power System	PEC	3	1	0	4	4
15	HV3051	Design of Substations	PEC	3	0	0	3	3
16	HV3153	Insulation Technology	PEC	3	0	0	3	3
17	CO3152	Intelligent Controllers	PEC	3	0	0	3	3
18	ET3054	Embedded Controllers for EV Applications	PEC	3	0	0	3	3
19	ET3062	MEMS and NEMS Technology	PEC	3	0	0	3	3
20	ET3065	Robotics and Automation	PEC	3	0	0	3	3
21	ET3059	Intelligent System Design	PEC	3	0	0	3	3
22	ET3052	Blockchain Technologies	PEC	3	0	0	3	3
23	ET3051	Big Data Analytics	PEC	3	0	0	3	3
24	ET3061	Machine Learning and Deep Learning	PEC	3	0	0	3	3

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EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			L	T	P		
1.	PS3311	Project Work I	0	0	12	6	III
2.	PS3411	Project Work II	0	0	24	12	IV
					TOTAL CREDITS	**18**	

SUMMARY

S.No.	Name of the Programme: M.E. POWER SYSTEMS ENGINEERING					
	SUBJECT AREA	**CREDITS PER SEMESTER**				**CREDITS TOTAL**
		I	**II**	**III**	**IV**	
1.	FC	3				**3**
2.	PCC	13	16			**29**
3.	PEC	3	6	9		**18**
4.	RMC	3				**3**
5.	EEC			6	12	**18**
6.	**TOTAL CREDIT**	**22**	**22**	**15**	**12**	**71**

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RM3151 RESEARCH METHODOLOGY AND IPR

L T P C	
2 1 0 3	

UNIT I RESEARCH PROBLEM FORMULATION 9

Objectives of research, types of research, research process, approaches to research; conducting literature review- information sources, information retrieval, tools for identifying literature, Indexing and abstracting services, Citation indexes, summarizing the review, critical review, identifying research gap, conceptualizing and hypothesizing the research gap

UNIT II RESEARCH DESIGN AND DATA COLLECTION 9

Statistical design of experiments- types and principles; data types & classification; data collection - methods and tools

UNIT III DATA ANALYSIS, INTERPRETATION AND REPORTING 9

Sampling, sampling error, measures of central tendency and variation,; test of hypothesis- concepts; data presentation- types of tables and illustrations; guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript; guidelines for writing thesis, research proposal; References – Styles and methods, Citation and listing system of documents; plagiarism, ethical considerations in research

UNIT IV INTELLECTUAL PROPERTY RIGHTS 9

Concept of IPR, types of IPR – Patent, Designs, Trademarks and Trade secrets, Geographical indications, Copy rights, applicability of these IPR; , IPR & biodiversity; IPR development process, role of WIPO and WTO in IPR establishments, common rules of IPR practices, types and features of IPR agreement, functions of UNESCO in IPR maintenance.

UNIT V PATENTS 9

Patents – objectives and benefits of patent, concept, features of patent, inventive steps, specifications, types of patent application; patenting process - patent filling, examination of patent, grant of patent, revocation; equitable assignments; Licenses, licensing of patents; patent agents, registration of patent agents.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, the student can

CO1: Describe different types of research; identify, review and define the research problem

CO2: Select suitable design of experiment s; describe types of data and the tools for collection of data

CO3: Explain the process of data analysis; interpret and present the result in suitable form

CO4: Explain about Intellectual property rights, types and procedures

CO5: Execute patent filing and licensing

REFERENCES:

1. Cooper Donald R, Schindler Pamela S and Sharma JK, “Business Research Methods”, Tata McGraw Hill Education, 11e (2012).
2. Soumitro Banerjee, “Research methodology for natural sciences”, IISc Press, Kolkata, 2022,
3. Catherine J. Holland, “Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets”, Entrepreneur Press, 2007.
4. David Hunt, Long Nguyen, Matthew Rodgers, “Patent searching: tools & techniques”, Wiley, 2007.
5. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, “Professional Programme Intellectual Property Rights, Law and practice”, September 2013.

Attested

PS3101 **COMPUTER AIDED POWER SYSTEM ANALYSIS** **L T P C**
3 0 0 3

UNIT I POWER FLOW ANALYSIS **9**
Overview of Gauss – Seidel method, Newton-Raphson method, Fast Decoupled Power Flow method, DC load flow, convergence properties, handling Q-max violation in constant matrix, inclusion of frequency effects, handling of discrete variable in load flow - introduction to restructured power system

UNIT II OPTIMAL POWER FLOW **9**
Problem statement; Solution of Optimal Power Flow (OPF) – The gradient method, Newton's method, Linear Sensitivity Analysis; LP methods – With real power variables only – LP method with AC power flow variables and detailed cost functions; Security constrained Optimal Power Flow; Interior point algorithm; Bus Incremental costs.

UNIT III HYDROTHERMAL SCHEDULING PROBLEM **9**
Hydrothermal scheduling problem: short term and long term-mathematical model, algorithm. Dynamic programming solution methodology for Hydro-thermal scheduling with pumped hydro plant: Optimization with pumped hydro plant-Scheduling of systems with pumped hydro plant during offpeak seasons: algorithm. Selection of initial feasible trajectory for pumped hydro plant-Pumped hydro plant as spinning reserve unit - generation of outage induced constraint - Pumped hydro plant as Load management plant.

UNIT IV POWER SYSTEM SECURITY **9**
Introduction to Power system security analysis and monitoring - DC Load flow - Factors affecting power system security - Contingency analysis for generator and line outages using linear sensitivity factors.

UNIT V STATE ESTIMATION **9**
Need for power system state estimation- Network observability – DC state estimation model- State estimation of power system – Methods of state estimation: Least square state estimation, weighted least square state estimation, Maximum likelihood- Bad data detection and identification.

TOTAL: 45 PERIODS

COURSE OUTCOMES
Students will be able to:
CO1: calculate voltage phasors at all buses, given the data using various methods of load flow
CO2: calculate OPF solutions for economic operation of power system
CO3: Analyze the optimal scheduling of power system with various generation mix
CO4: Rank various contingencies according to their severity
CO5: Estimate the bus voltage phasors given various quantities viz. power flow, voltages, taps,CB status etc.

REFERENCES

1. Allen.J.Wood and Bruce F.Wollenberg, 'Power Generation, Operation and Control', JohnWiley& Sons, Inc., 2003.
2. P. Kundur, 'Power System Stability & Control', McGraw Hill Publications,USA, 2006
3. Ali Abur&Antinio Gomez Exposito, 'Power System State Estimation Theory &Implementation', Marcel Dekker, Inc., Newyork,USA,2004.
4. Olle. I. Elgerd, 'Electric Energy Systems Theory – An Introduction', Tata McGraw HillPublishing Company Ltd,New Delhi, Second Edition, 2003.
5. D.P. Kothari and I.J. Nagrath, 'Modern Power System Analysis', Fourth Edition, TataMcGraw Hill Publishing Company Limited,New Delhi, 2011.
6. M.A.Pai," Computer Techniques in Power System Analysis",Tata McGraw-Hill Publishing Company Limited, New Delhi, 2006.

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MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	3	2	2
CO2	3	2	2	3	1	2
CO3	3	2	2	2	1	2
CO4	3	2	2	1	1	1
CO5	3	2	1	1	1	1
Average	**3**	**2**	**1.8**	**2**	**1.2**	**1.6**

PS3151 ANALYSIS AND COMPUTATION OF ELECTROMAGNETIC TRANSIENTS IN POWER SYSTEMS **L T P C 3 0 0 3**

UNIT I REVIEW OF TRAVELLING WAVE PHENOMENA 9

Lumped and Distributed Parameters – Wave Equation – Reflection, Refraction, Behaviour of Travelling waves at the line terminations – Lattice Diagrams – Attenuation and Distortion-switching overvoltage: Short line or kilometric fault, energizing transients - closing and re-closing of lines, methods of control; temporary over voltages: line dropping, load rejection; voltage induced byfault; very fast transient overvoltage(VFTO).

UNIT II PARAMETERS AND MODELLING OF OVER HEADLINES AND UNDER GROUND CABLES 9

Review of line parameters for simple configurations: series resistance, inductance and shunt capacitance; bundle conductors : equivalent GMR and equivalent radius; modal propagation in transmission lines: modes on multi-phase transposed transmission lines, α-β-0 transformation and symmetrical components transformation, modal impedances; analysis of modes on un-transposed lines; effect of ground return and skin effect; transposition schemes; introduction to frequency-dependent line modeling. Distinguishing features of underground cables: technical features, electrical parameters, overhead lines versus underground cables; cable types; series impedance and shunt admittance of single- core self-contained cables, impedance and admittance matrices for three phase system formed by three single-core self-contained cables; approximate formulas for cable parameters

UNIT III PARAMETERS AND MODELLING OF TRANSFORMER 9

Transformer modelling guidelines for transient phenomena – Generalization of [R]-[ωL] model single phase N-coil transformer-Generalization of [R]-[ωL]-1 model single phase N-coil transformer- Inverse Inductance Matrix representation of three-phase N-coil transformers- inclusion of exciting current.

UNIT IV INSULATION CO-ORDINATION 9

Insulation co-ordination –volt –time characteristics , Insulation strength and their selection-Evaluation of insulation strength standard BILs-Characteristics of protective devices, applications, location of arresters – insulation co-ordination in AIS and GIS

UNIT V COMPUTATION OF POWER SYSTEM TRANSIENTS 9

Digital computation of line parameters: why line parameter evaluation programs? salient features of a typical line parameter evaluation program; constructional features of that affect transmission line parameters; line parameters for physical and equivalent phase conductors elimination of ground wires bundling of conductors; principle of digital computation of transients: features and capabilities of electromagnetic transients program; steady state and time step solution modules: basic solution methods; case studies on simulation of various types of transients and insulation co-ordination.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Students will be able to:

CO1: Understand and analyse the different types of transients,travelling wave phenomeana.
CO2: Model overhead lines and cables and for transient studies.
CO3: Model transformers for transient studies.
CO4: Design a reliable power system with appropriate insulation coordination.
CO5: Compute different types of transients in power systems.

REFERENCES

1. Allan Greenwood, “Electrical Transients in Power System”, Wiley & Sons Inc.New York, 1991.
2. R. Ramanujam, Computational Electromagnetic Transients: Modelling, Solution Methods and Simulation, I.K. International Publishing House Pvt. Ltd, New Delhi -110 016, ISBN 978-93-82332-74-9, 2014; email: info@ikinternational.com
3. PritindraChowdhari, “Electromagnetic transients in Power System”, John Wiley and Sons Inc., Second Edition, 2009.
4. Rakosh Das Begamudre, “Extra High Voltage AC Transmission Engineering”, (Second edition) Newage International (P) Ltd., New Delhi,1990.
5. Naidu M S and Kamaraju V, “High Voltage Engineering”, Tata McGraw-Hill Publishing Company Ltd., New Delhi,2004.
6. Andrew R. Hileman, “Insulation Coordination for Power Systems”, CRC press, Taylor &Francis Group, New York, 1999.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	3	2	-	3
CO2	2	1	3	2	-	3
CO3	3	1	3	3	3	3
CO4	3	2	2	3	3	3
CO5	3	1	3	2	3	3
Average	**2.6**	**1.25**	**2.8**	**2.4**	**3**	**3**

PS3102 INDUSTRIAL POWER SYSTEM ANALYSIS AND DESIGN **L T P C**
3 0 0 3

UNIT I MOTOR STARTING STUDIES 9
Introduction-Evaluation Criteria-Starting Methods-System Data-Voltage Drop Calculations-Calculation of Acceleration time-Motor Starting with Limited-Capacity Generators-Computer-Aided Analysis- Conclusions.

UNIT II POWER FACTOR CORRECTION STUDIES 9
Introduction-System Description and Modeling-Acceptance Criteria-Frequency Scan Analysis-Voltage Magnification Analysis-Sustained Overvoltage's-Switching Surge Analysis-Back-to-Back Switching-Summary and Conclusions.

UNIT III HARMONIC ANALYSIS 9
Harmonic Sources-System Response to Harmonics-System Model for Computer-Aided Analysis-Acceptance Criteria-Harmonic Filters-Harmonic Evaluation-Case Study-Summary and Conclusions.

UNIT IV FLICKER ANALYSIS 9
Sources of Flicker-Flicker Analysis-Flicker Criteria-Data for Flicker analysis- Case Study-Arc Furnace Load-Minimizing the Flicker Effects-Summary.

UNIT V GROUND GRID ANALYSIS 9
Introduction-Acceptance Criteria-Ground Grid Calculations-Computer-Aided Analysis - Improving the Performance of the Grounding Grids-Conclusions.

TOTAL: 45 PERIODS

Students will be able to:
CO1: perform motor starting studies.
CO2: To model and carry out power factor correction studies.
CO3: Perform harmonic analysis and reduce the harmonics by using filters.
CO4: Carry out the flicker analysis by proper modeling of the load and its minimization.
CO5: Design the appropriate ground grid for electrical safety.

REFERENCES
1. Ramasamy Natarajan, "Computer-Aided Power System Analysis", Marcel Dekker Inc., 2002.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	-	1	-	-
CO2	1	2	1	1	1	-
CO3	1	2	-	1	-	-
CO4	1	2	2	1	2	1
CO5	1	-	3	1	2	2
Average	**1**	**2**	**2**	**1**	**1.66**	**1.5**

PS3152 **HVDC AND FACTS** **L T P C**
3 0 0 3

UNIT I INTRODUCTION 9

Review of basics of power transmission networks-control of power flow in AC transmission line-Analysis of uncompensated AC Transmission line- Passive reactive power compensation: Effect of series and shunt compensation at the mid-point of the line on power transfer- Need for FACTS controllers- types of FACTS controllers-Review of basics of LCC and VSC HVDC system.

UNIT II THYRISTOR BASED FACTS 9

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

UNIT III ANALYSIS OF LCC HVDC CONVERTERS AND HVDC SYSTEM CONTROL 9

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

UNIT IV VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS 9

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

UNIT V VOLTAGE SOURCE CONVERTER BASED MTDC SYSTEMS 9

Applications VSC based HVDC: Four quadrant Operation, dq control, PLL dynamics, per unit system for DC Quantities, Modelling for steady state analysis . - Modelling of DC links for dynamics, Solution of DC load flow-Solution of AC- DC power flow: Sequential and Simultaneous methods.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Students will be able to:

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

REFERENCES

1. P. Kundur, “Power System Stability and Control”, McGraw-Hill, 2006.
2. K.R.Padiyar, “HVDC Power Transmission Systems”, New Age International (P)Ltd., NewDelhi, 2002.
3. Mohan Mathur, R., Rajiv. K. Varma, “Thyristor – Based Facts Controllers for Electrical Transmission Systems”, IEEE press and John Wiley& Sons, Inc.
4. K.R.Padiyar,” FACTS Controllers in Power Transmission and Distribution”, New Age International(P) Ltd., Publishers, New Delhi, Reprint 2008.
5. J.Arrillaga, , “High Voltage Direct Current Transmission”, Peter Pregrinus, London, 1983.
6. Erich Uhlmann, “ Power Transmission by Direct Current”, BS Publications,2004.
7. V.K.Sood, HVDC and FACTS controllers – Applications of Static Converters in Power System, APRIL 2004 , Kluwer Academic Publishers.

8. A.T.John, “Flexible AC Transmission System”, Institution of Electrical and Electronic Engineers (IEEE), 1999.
9. NarainG.Hingorani, Laszio. Gyugyl, “Understanding FACTS Concepts and Technology of Flexible AC Transmission System”, Standard Publishers, Delhi 2001.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	3	2	-	3
CO2	3	1	3	2	2	3
CO3	3	1	3	3	2	3
CO4	3	2	3	3	2	3
CO5	3	2	3	2	2	3
Average	**2.6**	**1.5**	**3**	**2.4**	**2**	**3**

PS3111 POWER SYSTEM LABORATORY

L T P C
0 0 4 2

1. Power flow analysis by Newton-Raphson and Fast decoupled methods.
2. Contingencyanalysis:Generatorshiftfactorsandlineoutagedistributionfactors
3. State estimation of power systems.
4. Small-signal stability analysis of single machine-infinite bus system using classical machine model
5. Small-signal stability analysis of multi-machine configuration with classical machine model
6. Induction motor starting analysis
7. Available Transfer Capability calculation using an existing load flow program
8. Computation of harmonic indices generated by a rectifier feeding a R-L load
9. Design of active filter for mitigating harmonics.
10. Analysis of switching surge using EMTP: Energisation of a long distributed- parameter line
11. Analysis of switching surge using EMTP : Computation of transient recovery voltage for short line fault.
12. Locational Marginal Pricing computation of Restructured power systems

TOTAL: 60 PERIODS

COURSE OUTCOMES

CO1: Students will be able to gain Hands-on experience on various power system studies using user developed programs and validation of results using application software packages.
CO2: Students can gain practical knowledge on load flow analysis solved by various methods.
CO3: Students will be able to do stability analysis on single machine and multi machine configuration.
CO4: Students have learnt to calculate Available Transfer Capacity and Locational marginal pricing for Deregulated power system.
CO5: Experiments were conducted to mitigate and compute Harmonic indices.

Attested

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	-	1	-	1
CO2	1	2	1	2	2	1
CO3	1	2	-	2	2	1
CO4	1	2	2	2	-	-
CO5	1	-	1	2	2	2
Average	**1**	**2**	**1.33**	**1.8**	**2**	**1.25**

PS3112 HVDC AND FACTS LABORATORY **L T P C**
0 0 4 2

1) Effect of loading the transmission line-voltage profile along the entire stretch -coding and simulation using distributed parameter modelling of the line
2) Analysis of effect of midpoint compensation of a long transmission line. Simulation in PSCAD/EMTDC or EMTP/RV or PSS/E
3) Grid Emulation
4) Inclusion of SVC and TCSC in power flow analysis
5) Design of SVC voltage compensator and closed loop control
6) Design of TCSC and simulation for power flow enhancement capability
7) Design of STATCOM and closed loop control - Simulation in PSCAD/EMTDC or EMTP/RV
8) Design of SSSC and demonstration of power flow control and power reversal
9) Power flow management in LCC HVDC transmission system
10) DQ control of Two terminal VSC based transmission system- simulation
11) DQ control of Two terminal VSC based transmission system- hardware

TOTAL: 60 PERIODS

COURSE OUTCOMES:

CO1: Ability to analyze feature of SVC
CO2: Ability to analyze the difference in variable and fixed shunt and series compensation
CO3: Ability to model and design controllers for FACTS devices
CO4: Ability to test the and validate the controller design for FACTS and HVDC system
CO5: Ability to test the controller performance using Grid Emulator.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	2	-	3
CO2	2	1	3	2	2	3
CO3	2	1	3	3	2	3
CO4	2	2	3	3	2	3
CO5	2	2	3	2	2	3
Average	**2**	**1.4**	**3**	**2.4**	**2**	**3**

PS3201 ADVANCED POWER SYSTEM PROTECTION L T P C
3 0 0 3

UNIT I OVER CURRENT & EARTH FAULT PROTECTION 9

Zones of protection – Primary and Backup protection – operating principles and Relay Construction. Time – Current characteristics - Current setting – Time setting-Over current protective schemes – Concept of Coordination - Protection of parallel / ring feeders - Reverse power or directional relay – Polarisation Techniques – Cross Polarisation – Quadrature Connection - Earth fault and phase fault protection - Combined Earth fault and phase fault protection scheme - Phase fault protective - scheme directional earth fault relay - Static over current relays – numerical coordination example for a radial feeder

UNIT II DISTANCE AND CARRIER PROTECTION OF TRANSMISSION LINES 9

Braw back of over – Current protection – Introduction to distance relay – Simple impedance relay – Reactance relay – Mho relays – Disadvantages – Quadrilateral Characteristics - Comparison of distance relay – Distance protection of a three – Phase line-reasons for inaccuracy of distance relay reach - Three stepped distance protection – Effect of Source impedance & Earthing – Effect of Power Swing - Need for carrier – Aided protection – Various options for a carrier - Coupling and trapping the carrier into the desired line section - Unit type carrier aided directional comparison relaying – Carrier aided distance schemes – Permissive Under reach & Over reach schemes - Acceleration of Zone II faults - Numerical example for a typical distance protection scheme for a transmission line.

UNIT III EQUIPMENT PROTECTION 15

Types of transformers – Phasor diagram for a three – Phase transformer-Equivalent circuit of transformer – Types of faults in transformers- Over – current protection Percentage Differential Protection of Transformers - Inrush phenomenon-High resistance Ground Faults in Transformers - Inter-turn faults in transformers - Incipient faults in transformers - Phenomenon of over-fluxing in transformers Introduction to busbar protection – Differential protection of busbars-external and internal fault - Actual behaviors of a protective CT - Circuit model of a saturated CT - External fault with one CT saturation :need for high impedance – Minimum internal fault that can be detected by the high – Stability ratio of high impedance busbar differential scheme - Supervisory relay-protection of three – Phase busbars - Numerical examples on design of high impedance busbar differential scheme.

Introduction to generator protection - Electrical circuit of the generator – Various electrical faults and abnormal operating conditions – Stator Winding Faults – Protection against Stator (earth) faults – Rotor fault – Abnormal operating conditions - Protection against unbalanced loading - over speeding – Loss of excitation - loss of prime mover.

Attested

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UNIT IV NUMERICAL PROTECTION 6

Introduction – Block diagram of numerical relay - Sampling theorem- Correlation with a reference wave – Least error squared (LES) technique - Digital filtering-numerical over - Current protection – Numerical transformer differential protection - Numerical distance protection of transmission line

UNIT V SUBSTATION AUTOMATION 6

Introduction to Substation Automation – Topology – Hardware Implementation – Introduction to Digital Substation – Importance of Communications in Digital world – OSI Layer – Ethernet Communication – Introduction to Analog to Digital Transformation – Merging Units (MU) - Introduction to IEC 61850 – Advantages of IEC 61850

TOTAL: 45 PERIODS

COURSE OUTCOMES

CO1: Understand the various schemes of over current and earth fault protection
CO2: Gain knowledge on distance and carrier protection schemes
CO3: Attain knowledge equipment protections
CO4: Understand the concepts numerical protection
CO5: Attain basic knowledge on substation automation and controls.

REFERENCES

1. Y.G. Paithankar and S.R Bhide, "Fundamentals of Power System Protection", Prentice-Hall of India,2003
2. Badri Ram and D.N. Vishwakarma, "Power System Protection and Switchgear", Tata McGraw- Hill Publishing Company,2002.
3. P.Kundur, "Power System Stability and Control", McGraw-Hill,1993.
4. Protective Relaying for Power System II Stanley Horowitz,IEEE press , New York,2008
5. Network Protection & Automation Guide, Edition May 2011 – Alstom Grid.
6. T.S.M. Rao, Digital Relay / Numerical relays, Tata McGraw Hill, New Delhi,1989

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	2	2	1
CO2	2	2	2	3	3	2
CO3	2	3	2	2	2	1
CO4	1	2	3	3	2	2
CO5	2	3	3	3	2	1
Average	**1.8**	**2.4**	**2.4**	**2.6**	**2.2**	**1.4**

PS3251 RESTRUCTURED POWER SYSTEM L T P C
3 0 0 3

UNIT I INTRODUCTION 9

Deregulation of power industry, unbundling of electric utilities, Issues involved in deregulation – Fundamentals of Economics: Consumer and suppliers behavior, Total utility and marginal utility, Law of diminishing marginal utility, Elasticity of demand and supply curve, Market equilibrium, Consumer and supplier surplus, Global welfare, Deadweight loss - The Philosophy of Market Models: Monopoly model, Single buyer model, Wholesale competition model, Retail competition model, distinguishing features of electricity as a commodity, pillars of market design- Market power.

Attested

UNIT II TRANSMISSION CONGESTION MANAGEMENT 9

Importance of congestion management in deregulated environment - Classification of congestion management methods - Calculation of ATC - Non-market methods - Market based methods - Nodal pricing - Inter-zonal Intra-zonal congestion management - Price area congestion management - Capacity alleviation method.

UNIT III LOCATIONAL MARGINAL PRICES (LMP) AND FINANCIAL TRANSMISSION RIGHTS 9

Fundamentals of locational marginal pricing - Lossless DCOPF model for LMP calculation - Loss compensated DCOPF model for LMP calculation - ACOPF model for LMP calculation - Risk Hedging Functionality Of financial Transmission Rights - FTR issuance process - Treatment of revenue shortfall - Secondary trading of FTRs - Flow Gate rights - FTR and market power

UNIT IV ANCILLARY SERVICE MANAGEMENT AND PRICING OF TRANSMISSION NETWORK 9

Types of ancillary services - Load-generation balancing related services - Voltage control and reactive power support services - Black start capability service - Mandatory provision of ancillary services - Markets for ancillary services - Co-optimization of energy and reserve services - International comparison. Pricing of transmission network: wheeling - principles of transmission pricing - transmission pricing methods - Marginal transmission pricing paradigm - Composite pricing paradigm - loss allocation methods

UNIT V MARKET EVOLUTION 9

US markets: PJM market, Nordic power market, California energy market - Reforms in Indian power sector: Framework of Indian power sector, Reform initiatives, availability based tariff (ABT), The Electricity Act 2012, Open Access issues, Power exchange, role of RLDC, NLDC and ALDC.

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

CO1: Understand the process of restructuring of power industry and analyze the philosophy of market models

CO2: analyze various methods of congestion management in deregulated power system

CO3: analyze the locational marginal pricing and financial transmission rights

CO4: analyze the ancillary service management and wheeling charges

CO5: explain the evolution of Indian and US power markets

REFERENCES

1. Mohammad Shahidehpour, MuwaffaqAlomoush,“Restructured electrical powersy stems: operation, trading and volatility” Marcel Dekker Pub.,2001.
2. Kankar Bhattacharya, Math H.J.Boolen, and JaapE.Daadler, "Operation of restructured power systems”, Kluwer Academic Pub.,2001.
3. Sally Hunt, "Making competition work in electricity”, John Willey and Sons Inc. 2002.
4. Steven Stoft, " Power System Economics: Designing Markets for Electricity”, Wiley-IEEE Press, 2002.
5. S.A. Khaparde, A.R. Abhyankar, "Restructured Power Systems", NPTEL Course, https://nptel.ac.in/courses/108101005/.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	3	-	-
CO2	3	1	2	3	-	-
CO3	3	1	2	3	-	-
CO4	3	1	2	3	-	-
CO5	3	1	2	3	-	-
Average	**3**	**1**	**2**	**3**	**-**	**-**

Attested

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PS3252 **SMART GRID** **L T P C**
3 0 0 3

UNIT I INTRODUCTION TO SMART GRID 9

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

UNIT II SMART GRID TECHNOLOGIES (TRANSMISSION) 9

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

UNIT III SMART GRID TECHNOLOGIES (DISTRIBUTION) 9

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

UNIT IV SMART METERS AND ADVANCED METERING INFRASTRUCTURE 9

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

UNIT V COMMUNICATION PROTOCOLS FOR POWER SYSTEM AUTOMATION 9

Introduction to Communication Protocol, Comparison of Communication media and different communication network topologies Description of Different Communication Protocol - Physical based Protocol(RS-232,RS-485) - Layered Based Protocol(IEC-61850 - Substation Automation) (C37.118 - Wide Area Monitoring and Protection),(DNP3 - Distribution Automation),MODBUS.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Students will be able to:

CO1: Understand on the concepts of Smart Grid and its present developments.
CO2: Analyze about different Smart Grid transmission technologies.
CO3: Analyze about different Smart Grid distribution technologies.
CO4: Acquire knowledge about different smart meters and advanced metering infrastructure.
CO5: Develop more understanding on LAN, WAN and Cloud Computing for Smart Grid applications.

REFERENCES

1. Stuart Borlase “Smart Grid :Infrastructure, Technology and Solutions”,CRC Press 2016.
2. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, “Smart Grid: Technology and Applications”,Wiley.
3. Vehbi C. Gungor, DilanSahin, TaskinKocak, SalihErgut, ConcettinaBuccella, Carlo Cecati ,and Gerhard P. Hancke, Smart Grid Technologies: Communication Technologies and Standards IEEE Transactions On Industrial Informatics, Vol. 7, No. 4, November 2011.
4. Xi Fang, SatyajayantMisra, GuoliangXue, and Dejun Yang “Smart Grid – The New and Improved Power Grid: A Survey” , IEEE Transaction on Smart Grid

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	-	1	-	-
CO2	1	2	-	1	1	1
CO3	1	2	-	1	2	-
CO4	1	-	-	1	1	2
CO5	1	2	2	1	-	2
Average	**1**	**2**	**2**	**1**	**1.33**	**1.67**

PS3202 POWER SYSTEM DYNAMICS

L	T	P	C
3	0	0	3

UNIT I SYNCHRONOUS MACHINE MODELLING 9

Schematic Diagram, Physical Description: armature and field structure, machines with multiple pole pairs, mmf waveforms, direct and quadrature axes, Mathematical Description of a Synchronous Machine: Basic equations of a synchronous machine: stator circuit equations, stator self, stator mutual and stator to rotor mutual inductances, dq0 Transformation: flux linkage and voltage equations for stator and rotor in dq0 coordinates, electrical power and torque, physical interpretation of dq0 transformation, Equivalent Circuits for direct and quadrature axes, Steady-state Analysis: Voltage, current and flux-linkage relationships, Phasor representation, Rotor angle Steady-state equivalent circuit, Computation of steady-state values, Equations of Motion: Swing Equation, calculation of inertia constant, Representation in system studies, Synchronous Machine Representation in Stability Studies: Simplifications for large-scale studies

UNIT II MODELLING OF EXCITATION AND SPEED GOVERNING SYSTEMS 9

Excitation System Requirements; Elements of an Excitation System; Types of Excitation System; Control and protective functions; IEEE (1992) block diagram for simulation of excitation systems. Turbine and Governing System Modelling: Functional Block Diagram of Power Generation and Control, Schematic of a hydroelectric plant, classical transfer function of a hydraulic turbine (no derivation), special characteristic of hydraulic turbine, electrical analogue of hydraulic turbine, Governor for Hydraulic Turbine: Requirement for a transient droop, Block diagram of governor with transient droop compensation, Steam turbine modelling: Single reheat tandem compounded type only and IEEE block diagram for dynamic simulation; generic speed-governing system model for normal speed/load control function.

UNIT III SMALL-SIGNAL STABILITY ANALYSIS 9

Classification of Stability, Basic Concepts and Definitions: Rotor angle stability, The Stability Phenomena. Fundamental Concepts of Stability of Dynamic Systems: State- space representation, stability of dynamic system, Linearization, Eigen properties of the state matrix: Eigen values and eigenvectors, modal matrices, Eigen value and stability, mode shape and participation factor. Single- Machine Infinite Bus (SMIB) Configuration: Classical Machine Model stability analysis with numerical example, Effects of Field Circuit Dynamics: synchronous machine, network and linearized system equations, block diagram representation with K- constants; expression for K-constants (no derivation), effect of field flux variation on system stability: analysis with numerical example. Effects Of Excitation System-Enhancement of small signal stability

UNIT IV TRANSIENT STABILITY ANALYSIS 9

Review of numerical integration methods: Euler and Fourth Order Runge-Kutta methods, Numerical stability and implicit methods, Interfacing of Synchronous machine (variable voltage) model to the transient stability algorithm (TSA) with partitioned – explicit and implicit approaches – Interfacing SVC with TSA-Methods To Enhance Transient Stability.

UNIT V VOLTAGE STABILITY ANALYSIS 9

Classification Of Voltage Stability-Basic Concept Related To Voltage Stability: Transmission System Characteristics, Generator Characteristics, Load Characteristics, Characteristics Of Reactive Compensating Devices- Voltage Collapse: Typical Scenario Of Voltage Collapse, Voltage Factor That Affect Voltage Stability-Voltage Stability Analysis: Mode Dynamic Analysis, Static Analysis-Prevention Of Voltage Collapse.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Students will be able to:

CO1: Model the synchronous machine for stability analysis.
CO2: Model of excitation and speed governing system for stability analysis.
CO3: Analyze the small signal stability of power systems with controllers.
CO4: Analyze the rotor angle stability of the system stability by explicit and implicit methods of integration.
CO5: Investigate voltage stability of power system.

REFERENCES

1. R.Ramanujam,” Power System Dynamics Analysis and Simulation, PHI Learning Private Limited, Second print, New Delhi,2013
2. P. Kundur, “Power System Stability and Control”, McGraw-Hill,1993.
3. P. W. Sauer and M. A. Pai,” Power System Dynamics and Stability”, Stipes Publishing Co,2007
4. IEEE Committee Report, "Dynamic Models for Steam and Hydro Turbines in Power System Studies”, IEEE Trans., Vol.PAS-92, pp 1904-1915, November/December, 1973.on Turbine-Governor Model.
5. P.M Anderson and A.A Fouad, “Power System Control and Stability”, Iowa State University Press, Ames,Iowa, 1976

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	3	2	-	3
CO2	3	1	3	2	2	3
CO3	3	1	3	3	2	3
CO4	3	1	3	3	2	3
CO5	3	1	3	2	2	3
Average	**3**	**1**	**3**	**2.4**	**2**	**3**

PS3211 POWER SYSTEM PROTECTION LABORATORY L T P C
0 0 4 2

1. Understanding feature of injection of V&I along with control parameters (Magnitude, Frequency, Phase angle) and verify with DSO 2. Ramping feature of V&I and verify with DSO.
3. Testing Different characteristics of curve (IEC – NI, VI, LTI, and EI).
4. Verification of Non-directional OC/EF along with different RCA/MTA with Inrush phenomena.
5. Analysis of High impedance and Low impedance biased current differential protection for transformers.
6. Testing of Low impedance biased Current Differential protection with Simulation of excitation failure of generator by PSCAD/EMTDC and implementation of protection settings and verifying relay characteristics.

7. Testing of relay characteristics of Out of step considering Generator side fault and Power swing of Power system side.
8. Study of Numerical Transformer / Distance Protection with Relay test kit.
9. Hardware-in-loop simulation with generator protection relay and real-time digital simulator.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

CO1: Ability to analyze feature of V&I and verify with DSO
CO2: Ability to analyze the different characteristics curves
CO3: Ability to analyze the relay with inrush phenomena
CO4: Ability to test the differential protection by PSCAD/EMTDC
CO5: Ability to test the Numerical Transformer / Distance Protection with Relay test kit.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3	2	-	3
CO2	2	2	3	2	2	3
CO3	2	3	3	3	2	3
CO4	3	3	3	3	2	3
CO5	3	3	3	2	2	3
Average	**2.4**	**2.6**	**3**	**2.4**	**2**	**3**

PS3212 POWER SYSTEM MICRO GRID LABORATORY **L T P C**
0 0 4 2

EXPERIMENTS:

1. Calibration of voltage and current sensors
2. Performance characteristics of solar PV panel.
3. Performance of PV panel in series and parallel combination.
4. Battery Modelling andSOC estimation
5 Modelling and controller implementation of Buck converters using any Processor- firing pulse generation -hardware implementation
6. Modelling and controller implementation of Buckboost converters using any Processor-- firing pulse generation hardware implementation
7. MPPT tracking of DFIG based WT.-hardware implementation in closed loop
8. MPPT tracking of PMSG based WT
9. Grid integration of RES.

TOTAL: 60 PERIODS

COURSE OUTCOMES

CO1: Students will understand the characteristics of various renewable energy sources.
CO2: Students will be able to program different MPPT algorithm and understand their merits and demerits
CO3: Students will learn control of DFIG .
CO4: Students will learn control of PMSG .
CO5: Students will design and model PV system integration with grid.

Attested

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	1	-	-
CO2	3	3	3	1	-	-
CO3	3	3	3	1	-	-
CO4	3	3	3	1	-	-
CO5	3	3	3	1	-	-
Average	**3**	**3**	**3**	**1**	**-**	**-**

PROFESSIONAL ELECTIVES

PS3001 POWER SYSTEM STATE ESTIMATION AND SECURITY ASSESSMENT

L	T	P	C
3	0	0	3

UNIT I INTRODUCTION TO STATE ESTIMATION 9

Need for state estimation – Measurements – Noise - Measurement functions – Measurement Jacobian– Weights - Gain matrix - State estimation as applied to DC networks - Comparison of Power flow andState Estimation problems - Energy Management System.

UNIT II WEIGHTED LEAST SQUARE ESTIMATION 9

Modeling of transmission lines - Shunt capacitors and reactors - Tap changing and phase shifting transformers - loads and generators - Building network models - Maximum likelihood estimation - Measurement model and assumptions - WLS State Estimation Algorithm - Measurement functions - Measurement Jacobian matrix - Gain matrix - Cholesky decomposition and performing forward and backward substitutions - Decoupled formulation of WLS State estimation - DC State estimation model - Role of Phasor Measurement Units (PMU) in state estimation.

UNIT III ALTERNATIVE FORMULATION OF WLS STATE ESTIMATION 9

Weakness of normal equation formulation, Orthogonal factorization, Hybrid method, Method of Peters and Wilkinsons, Equality constraints WLS State estimation, Augmented matrix approach, Blocked formulation and comparison of techniques.

UNIT IV NETWORK OBSERVABILITY AND BAD DATA DETECTION IDENTIFICATION 9

Network and graphs, Network matrices, loop equations, Methods Observability analysis, Numerical Method based on Nodal Variable formulation and branch variable formulation, Topological Observability analysis, Determination of critical measurements – Role of PMU in network observability. Properties of measurement residuals - Classification of measurements - Bad data detection and identification using Chi-squares distribution and normalized residuals - Bad data identification - Largest normalized residual test and Hypothesis testing identification. bad data detection using PMU

Attested

UNIT V POWER SYSTEM SECURITY ASSESSMENT 9

Introduction to Security Assessment -Static Security Assessment-Summary of Different Types of Static Security Indices - Methods for Assessing Power System Security-Methods for Assessing Power System Security-Dynamic Security Assessment-Future Trends to Assessing Dynamic Security-Issues Related to Integration of Renewable Energies-Security Enhancement-Issues and Methods to Solve SCOPF Problem-Deal with the Challenges for Enhancing Dynamic Security.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Students able to

CO1: Define various concepts implied in State estimation and its need in DC networks.

CO2: Apply State estimation algorithms in modelling of transmission lines.

CO3: Compare the different types of formulation techniques of State estimation.

CO4: Analyse network observability and identify the bad data detection using different methods.

CO5: List the different types of assessing power system security and solve the issues.

REFERENCES

1. Ali Abur and Antonio Gomez Exposito ,"Power System State Estimation Theory and Implementation", Marcel Dekker, Inc., New York .Basel, 2004.
2. J J Grainger and W D Stevension, " Power System Analysis", McGraw-Hill, Inc., 1994.
3. A Monticelli, "State Estimation in Electric Power Systems", Kluwer Academic Publishers,1999.
4. Mukhtar Ahmad, "Power System State Estimation", Lap Lambert Acad Publishers,2013.
5. Felix L. Chernousko, " State Estimation for Dynamic Systems", CRC Press, 1993
6. Naim Logic, "Power System State Estimation" , LAP Lambert Acad. Publ., 2010.
7. Power System Security Assessment and Enhancement: A Bibliographical Survey.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	-	-	1	-	-
CO2	1	1	1	1	-	-
CO3	1	2	-	1	-	-
CO4	1	1	1	1	1	2
CO5	1	-	1	1	1	1
Average	**1**	**1.33**	**1**	**1**	**1**	**1.5**

PS3002 COMPUTER RELAYING AND WIDE AREA MEASUREMENT SYSTEMS

L	T	P	C
3	0	0	3

UNIT I INTRODUCTION 9

Historical background - Expected benefits - Computer relay architecture - Analog to digital converters -Anti-aliasing filters - Substation computer hierarchy - Fourier series Exponential Fourier series - Sine and cosine Fourier series – Phasor.

UNIT II FILTERS IN COMPUTER RELAYING 9

Walsh functions - Fourier transforms - Discrete Fourier transform - Random processes - Filtering of random processes - Kalman filtering - Digital filters - Windows and windowing - Linear phase Approximation - Filter synthesis – Wavelets - Elements of artificial intelligence.

UNIT III COMPUTATION OF PHASORS 9

Introduction - Phasor representation of sinusoids - Fourier series and Fourier transform and DFT Phasor representation - Phasor Estimation of Nominal Frequency Signals - Formulas for updating phasors – Non-recursive updates - Recursive updates - Frequency Estimation.

UNIT IV PHASOR MEASUREMENT UNITS 9

A generic PMU - The global positioning system - Hierarchy for phasor measurement systems - Functional requirements of PMUs and PDCs - Transient Response of: Phasor Measurement Units, of instrument transformers, filters. Transient response during electromagnetic transients and power swings.

UNIT V PHASOR MEASUREMENT APPLICATIONS 9

State Estimation - History, Operator's load flow - Weighted least square: least square, Linear weighted least squares, Nonlinear weighted least squares - Static state estimation - State estimation with Phasors measurements - Linear state estimation – Protection system with phasor inputs: Differential and distance protection of transmission lines - Adaptive protection - Adaptive out-of-step protection..

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Students able to

CO1 Demonstrate knowledge of fundamental theories, principles and practice of computer relaying, Wide area measurement system

CO2 Analyze the power system with computer relaying and Wide area measurement system

CO3 Validate the recent relaying technologies which work towards smart grid

CO4 Design wide area measurement systems for Smart grid.

CO5 Compare the performance of modern relaying schemes and measurement techniques with the conventional one.

REFERENCES:

1. A.G. Phadke, J.S. Thorp, "Computer Relaying for Power Systems", John Wiley and Sons Ltd., Research Studies Press Limited, 2nd Edition, 2009.
2. A.G. Phadke, J.S. Thorp, "Synchronized Phasor Measurements and Their Applications", Springer, 2008
3. AntonelloMonti, Carlo Muscas, FerdinandaPonci,"Phasor Measurement Units and Wide Area

Attested

Monitoring Systems" Academic Press, 09-Jun-2016
4. Stanley H. Horowitz, Arun G. Phadke, "Power System Relaying", John Wiley & Sons, 25-Oct-2013.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	1	1	2	-
CO2	2	1	1	1	2	-
CO3	2	1	1	1	2	-
CO4	2	1	1	1	2	-
CO5	2	1	1	1	2	-
Average	**2**	**1**	**1**	**1**	**2**	**-**

PS3053 OPTIMIZATION TECHNIQUES TO POWER SYSTEM ENGINEERING L T P C
3 0 0 3

UNIT I CLASSICAL OPTIMIZATION TECHNIQUES 9
Historical Development, Engineering Applications of Optimization, Statement of Optimization Problem. Single variable optimization, Multivariable optimization with no constraints; Multivariable optimization with Equality constraints – Solution by Direct Substitution method, Method of constrained variation, Method of Lagrangian multipliers; Multivariable optimization with inequality constraints: Kuhn-Tucker conditions – solution of economic dispatch problem.

UNIT II LINEAR PROGRAMMING 9
Introduction, Applications of Linear Programming, Standard Form of a Linear Programming, Basic Terminology and Definitions, Exceptional cases, Simplex method, Revised Simplex method, Duality.

UNIT III NONLINEAR PROGRAMMING 9
Steepest descent method, conjugates gradient method, Newton's Method, Sequential quadratic programming, Penalty function method, augmented Lagrange multiplier method.

UNIT IV DYNAMIC PROGRAMMING 9
Multistage decision processes, concept of sub-optimization and principle of optimality – solution of unit commitment problem.

UNIT V GENETIC ALGORITHM 9
Introduction to genetic Algorithm, working principle, coding of variables, fitness function, GA operators; Similarities and differences between Gas and traditional methods; Unconstrained and constrained optimization using genetic Algorithm, global optimization using GA, Applications to power system problems.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
Upon the successful completion of the course, students will be able to:
CO1: learn about different classifications of optimization problems and classical optimization techniques.
CO2: analyze linear programming problems
CO3: analyze non-linear programming problems

CO4: explain the concepts of dynamic programming
CO5: explain Genetic algorithm and its application to power system optimization problems.

REFERENCES:

1. SingiresuS. Rao, “Engineering Optimization – Theory and Applications”, Third Edition, John Wiley & Sons, Inc., 1996.
2. Luenberger G., “Introduction of Linear and Non-Linear Programming”, Wesley Publishing Company, 2011.
3. Taha, H.A., “Operations Research—an Introduction”, Tenth Edition, Pearson Education, 2019.
4. Vohra, N.D., “Quantitative Techniques in Management”, Fifth Edition, Tata McGraw-Hill Education, 2017.
5. Rardin, R.L., “Optimization in operations research: Upper Saddle River”, Second Edition, Pearson, 2017.
6. Kothari, D.P. and Dhillon, J.S., “Power system optimization”, Second Edition, PHI Learning Private Limited, 2010.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	-	1	-	-
CO2	2	-	-	1	-	-
CO3	2	-	-	1	-	-
CO4	2	-	-	1	-	-
CO5	2	-	-	1	-	-
Average	**2**	-	-	**1**	-	-

PS3054 WIND ENERGY CONVERSION SYSTEMS **L T P C**
3 0 0 3

UNITI INTRODUCTION 9
Components of WECS-WECS schemes-Power obtained from wind-simple momentum theory-Power coefficient-Sabinin’s theory-Aerodynamics of Wind turbine

UNIT II WINDTURBINES 9
HAWT-VAWT-Power developed-Thrust-Efficiency-Rotor selection-Rotor design considerations- Tip speed ratio-No. Of Blades-Blade profile-Power Regulation-yaw control-Pitch angle control- stall control-Schemes for maximum power extraction.

UNIT III FIXED SPEED SYSTEMS 9
Generating Systems- Constant speed constant frequency systems -Choice of Generators-Deciding factors-Synchronous Generator-Squirrel Cage Induction Generator- Model of Wind Speed- Model wind turbine rotor - Drive Train model- Generator model for Steady state and Transient stability analysis.

UNIT IV VARIABLE SPEED SYSTEMS 9
Need of variable speed systems-Power-wind speed characteristics-Variable speed constant frequency systems synchronous generator- DFIG- PMSG -Variable speed generators modelling - Variable speed variable frequency schemes.

Attested

UNIT V GRIDCONNECTED SYSTEMS 9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES

Students will be able to:

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

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

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

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

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

REFERENCES

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

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	2	2	-	2
CO2	3	1	2	2	2	2
CO3	3	1	3	3	2	3
CO4	3	2	3	3	2	3
CO5	3	2	3	2	2	3
Average	**2.6**	**1.5**	**2.2**	**2.4**	**2**	**2.2**

PS3052 DISTRIBUTED GENERATION AND MICRO GRID

L	T	P	C
3	0	0	3

UNIT I INTRODUCTION TO DISTRIBUTED GENERATION 9

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

UNIT II DISTRIBUTED ENERGY RESOURCES 9

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

Attested

UNIT III DG PLANNING AND PROTECTION 9

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

UNIT IV AC MICROGRID 9

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

UNIT V DC MICROGRID 9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Students able to

CO1: Understand the concepts of Distributed Generation and Microgrids.

CO2: Gain Knowledge about the various DG resources.

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

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

CO5: Acquire knowledge on the impacts of Microgrid.

REFERENCES:

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

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	-	1	-	-
CO2	1	1	1	2	1	-
CO3	1	2	-	1	1	1
CO4	1	1	2	1	2	-
CO5	1	-	1	1	-	1
Average	**1**	**1.33**	**1.33**	**1.2**	**1.33**	**1**

Attested

PS3051 COMPUTATIONAL INTELLIGENCE TECHNIQUES TO POWER SYSTEMS

L	T	P	C
3	0	0	3

UNIT I ARTIFICIAL NEURAL NETWORKS (ANN) 9

Introduction to Artificial Neural Networks - Definition and Fundamental concepts - Biological Neural Network – Modeling of a Neuron -Activation functions – initialization of weights - Typical architectures-Leaning/Training laws - Supervised learning Unsupervised learning – Reinforcement learning-Perceptron – architectures-Linear Separability – Multi – layer perceptron using Back propagation Algorithm (BPA) – Application to Load forecasting.

UNIT II DEEP LEARNING 9

Introduction to deep neural networks - loss functions and optimization - regularization methods - convolutional neural networks - transfer learning- recurrent neural networks - long short-term memory and gated recurrent unit - deep belief network - Maximum Power Point Tracking of PV Grids using Deep Learning.

UNIT III FUZZY LOGIC 9

Introduction – Fuzzy versus crisp – Fuzzy sets – Membership function – Basic Fuzzy set operations – Properties of Fuzzy sets – Fuzzy cartesian Product – Operations on Fuzzy relations – Fuzzy logic – Fuzzy Quantifiers – Fuzzy Inference – Fuzzy Rule based system – Defuzzification methods – Application to Load frequency control and Reactive power control.

UNIT IV GENETIC ALGORITHM AND PARTICLE SWARM OPTIMIZATION 9

Genetic algorithms- Genetic Algorithm versus Conventional Optimization Techniques - Genetic representations and selection mechanisms; Genetic operators- different types of crossover and mutation operators -Bird flocking and Fish Schooling – anatomy of a particle- equations based on velocity and positions -PSO topologies - control parameters- Application to Economic load dispatch.

UNIT V MULTI OBJECTIVE OPTIMIZATION 9

Introduction- Concept of Pareto optimality - Non-dominant sorting technique-Pareto fronts-best compromise solution-min-max method-NSGA-II algorithm and application to general two objective optimization problem - Application to combined economic emission dispatch.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: analyze functional operation of a ANN and their bio-foundations
CO2: analyze functional operation of deep neural networks
CO3: design and develop fuzzy logic for simple control applications
CO4: design and develop genetic algorithms and particle swarm optimization for simple systems
CO5: solve multi-objective optimization problems to obtain Pareto fronts

REFERENCES

1. Sridhar S., and Vijayalakshmi M., "MACHINE Learning", Oxford University Press, First Edition, 2021.
2. Rajasekaran S. and Pai G.A.V., “Neural Networks, Fuzzy Logic & Genetic Algorithms”, PHI, New Delhi, 2008.
3. Kalyanmoy Deb, “Multi-Objective Optimization using Evolutionary Algorithms”, John Wiley & Sons, 2001.
4. Kothari, D.P. and Dhillon, J.S., “Power system optimization”, Second Edition, PHI Learning Private Limited, 2010.

Attested

5. Weerakorn Ongsakul and Vo Ngoc Dieu, “Artificial Intelligence in Power System Optimization”, CRC Press, 2013.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	-	-	2
CO2	3	1	2	-	-	2
CO3	3	1	2	-	-	2
CO4	3	1	2	-	-	2
CO5	3	1	2	-	-	2
Average	**3**	**1**	**2**	-	-	**2**

PS3003 POWER SYSTEM PLANNING AND RELIABILITY

L	T	P	C
3	0	0	3

UNIT I LOAD FORECASTING 9

Objectives of forecasting - Load growth patterns and their importance in planning – Load forecasting Based on discounted multiple regression technique-Weather sensitive load forecasting - Determination of annual forecasting-Use of AI in load forecasting.

UNIT II GENERATION SYSTEM RELIABILITY ANALYSIS 9

Probabilistic generation and load models- Determination of LOLP and expected value of demand not served –Determination of reliability of ISO and interconnected generation systems.

UNIT III TRANSMISSION SYSTEM RELIABILITY ANALYSIS 9

Deterministic contingency analysis-probabilistic load flow-Fuzzy load flow probabilistic transmission system reliability analysis-Determination of reliability indices like LOLP and expected value of demand not served.

UNIT IV EXPANSION PLANNING 9

Basic concepts on expansion planning-procedure followed for integrate transmission system planning, current practice in India-Capacitor placer problem in transmission system and radial distributions system.

UNIT V DISTRIBUTION SYSTEM PLANNING OVERVIEW 9

Introduction, sub transmission lines and distribution substations-Design primary and secondary systems-distribution system protection and coordination of protective devices.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Students will be able to:

CO1: Develop the ability to learn about load forecasting.
CO2: learn about reliability analysis of ISO and interconnected systems.
CO3: Understand the concepts of Contingency analysis and Probabilistic Load flow analysis
CO4: Understand the concepts of Expansion planning
CO5: Understand the fundamental concepts of the Distribution system planning

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

REFERENCES
1. Reliability Evaluation of Power System - Roy Billinton & Ronald N. Allan, Springer Publication
2. Power System Planning - R.L. Sullivan, Tata McGraw Hill Publishing Company Ltd.
3. Modern Power System Planning – X. Wang & J.R. McDonald, McGraw Hill Book Company
4. Electrical Power Distribution Engineering - T. Gonen, McGraw Hill Book Company
5. Generation of Electrical Energy – B.R. Gupta, S. Chand Publication

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	-	-	-	1
CO2	1	1	2	1	2	-
CO3	2	1	2	1	2	-
CO4	1	-	1	1	1	-
CO5	1	1	1	-	-	-
Average	**1.2**	**1**	**1.5**	**1**	**1.7**	**1**

PW3251 ENERGY STORAGE SYSTEMS **L T P C**
3 0 0 3

UNIT I INTRODUCTION **9**
Necessity for Energy Storage – Types of Energy Storage – Comparison of Energy Storage Technologies – Applications

UNIT II MECHANICAL ENERGY STORAGE SYSTEM **9**
Overview - Pumped Hydroelectric Storage (PHS) – Compressed-Air Energy Storage (CAES) – Various CAES – Flywheel Energy Storage (FES) – Comparison of PHS, CAES and FES

UNIT III ELECTROCHEMICAL ENERGY STORAGE **9**
Fundamental concept of Batteries – measuring the battery performance, charging and Discharging of a battery, Power Density - Energy Density – C-Rate – Spider Diagram of Battery- Battery Energy Storage Systems (BESS) – Lead Acid Battery - Nickel – Cadmium Batteries - Lithium-ion Batteries – High Temperature Batteries **–** Metal – Air Batteries **-** Flow Batteries

UNIT IV FUEL CELL **9**
History of Fuel Cell – Construction - Working Principle of Fuel Cell – Types – Hydrogen Fuel cells, Proton Exchange Membrane Fuel Cell, Solid Oxide Fuel Cell – Advantages and Disadvantages

UNIT V ALTERNATE ENERGY STORAGE TECHNOLOGIES **9**
Super capacitors, Principle – Applications, Superconducting Magnetic Energy Storage - Concept of Hybrid Storage – Applications, - Hydrogen Production - Hydrogen Storage Technologies - Safety and Management of Hydrogen Storage – Power to Gas Technology (P2G)

TOTAL: 45 PERIODS

Attested

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

CO1: Gained knowledge of various storage technologies
CO2: Understand the mechanical storage system
CO3: Do performance analysis of Various Battery Energy Storage System
CO4: Analyze the operation of fuel cell
CO5: Gain Knowledge on various types of alternate storage technologies and perform the selection based on techno-economic viewpoint.

REFERENCES:

1. David Linden, Thomas B.Reddy, "Handbook of Batteries", Third Edition, Tata Mc-Graw Hill, 2002.
2. James Larminie, Andrew Dicks, "Fuel cell Systems Explained", Third Edition, Wiley, 2018.
3. Ru-Shi Liu, Lei Zhang and Xueliang Sun, "Electrochemical Technologies for Energy Storage and Conversion", First Edition, Wiley, 2012.
4. P.Jayarama Reddy, "Principles of Energy Storage Systems", BS Publications, Hyderabad, First Edition, 2022.
5. G.D.Rai, "Non-Conventional Energy Sources", VI Edition Khanna Publishes, First Edition, 2017.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	-	1	2
CO2	2	1	3	-	1	2
CO3	2	1	3	-	1	2
CO4	2	1	3	-	1	2
CO5	2	1	3	-	1	2
Average	**2**	**1**	**3**	**-**	**1**	**2**

PW3052 ELECTRIC VEHICLES AND POWER MANAGEMENT **LT P C**
3 0 0 3

UNIT I HYBRID ELECTRIC VEHICLE ARCHITECTURE AND POWER TRAIN COMPONENTS 9

History of Evolution of Electric Vehicles (EV) - Comparison of Electric Vehicles with Internal Combustion Engines - Architecture of Electric Vehicles (EV) and Hybrid Electric Vehicles (HEV) – Plug-in Hybrid Electric Vehicles (PHEV)- Power Train Components and Sizing, Gears, Clutches, Transmission and Brakes

UNIT II MECHANICS OF HYBRID ELECTRIC VEHICLES 9

Fundamentals of Vehicle Mechanics - Tractive Force, Power and Energy Requirements for Standard Drive Cycles of HEV's - Motor Torque - Power Rating and Battery Capacity

UNIT III CONTROL OF DC AND AC MOTOR DRIVES 9

Speed control for Constant Torque, Constant HP operation of all Electric Motors - DC/DC chopper based Four Quadrant Operation of DC Motor Drives, Inverter-based V/f Operation (motoring and braking) of Induction Motor Drives, Vector Control Operation of Induction Motor and PMSM, Brushless DC Motor Drives, Switched Reluctance Motor (SRM) Drives

Attested

UNIT IV ENERGY STORAGE SYSTEMS **9**

Battery: Principle of operation, Types, Estimation Of Parameters, Battery Modeling, SOC of Battery, Traction Batteries and their capacity for Standard Drive Cycles, Vehicle to Grid operation of EV's -Alternate sources: Fuel cells, Ultra capacitors, Fly wheels

UNIT V HYBRID VEHICLE CONTROL STRATEGY AND ENERGY MANAGEMENT **9**

HEV Supervisory Control - Selection of modes - Power Spilt Mode - Parallel Mode - Engine Brake Mode - Regeneration Mode - Series Parallel Mode - Energy Management of HEV's

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Learn the electric vehicle architecture and power train components.

CO2: Acquire the concepts of dynamics of Electrical Vehicles.

CO3: Understand the vehicle control for Standard Drive Cycles of Hybrid Electrical Vehicles (HEVs).

CO4: Ability to model and understand the Energy Storage Systems for EV.

CO5: Acquire the knowledge of different modes and Energy Management in HEVs.

REFERENCES:

1. Iqbal Husain, “Electric and Hybrid Electric Vehicles”, First Edition, CRC Press, 2011
2. Wei Liu, “Hybrid Electric Vehicle System Modeling and Control”, Second Edition, Wiley, 2017
3. James Larminie and John Lowry, “Electric Vehicle Technology Explained”, Second Edition, 2012
4. Mehredad Ehsani, Yimi Gao, Stefano Longo and Kambiz Ebrahimi,” Modern Electric, Hybrid Electric and Fuel cell Vehicles”, Third edition, CRC Press, 2019
5. Jingsheng Yu and Vladimir V. Vantsevich, “Control Application of Vehicle Dynamics”, First Edition, CRC Press, 2021

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	1	-	3
CO2	3	1	2	1	-	3
CO3	3	1	2	1	-	3
CO4	3	1	2	1	-	3
CO5	3	1	2	1	-	3
Average	**3**	**1**	**2**	**1**	**-**	**3**

PW3057 **RENEWABLE ENERGY TECHNOLOGY** **L T P C**
3 0 0 3

UNIT I INTRODUCTION **9**

Renewable Energy Sources Vs Non-Renewable Energy Sources - Global Renewable Energy (RE) Availability - RE Resources available in India: Current Generation and utilization of RE Resources in India - Potential of Renewable Energy in Power Production and Need for Renewable Energy Technology – Non-Conventional Energy (NCE) for Rural India – NCE and Cost.

UNIT II SOLAR ENERGY 9

Solar Radiation and its measurements - Solar Thermal Energy Conversion from Solar Plate Collectors and Concentrating Collectors (CC) – CC : Types – Classification –Applications of Solar Thermal Energy: Solar Water Heating system - Direct Solar Electricity Conversion from Photovoltaics - Types of Solar Cells – Solar Photovoltaic (SPV) Systems: On-grid and Off-grid SPV System - Applications: Domestic Lighting, Solar Street Lighting, Rural Irrigation, Solar Powered Refrigerator - Building Integrated Photovoltaic (BIPV) – Building Adaptive Photovoltaic (BAPV)

UNIT III WIND ENERGY 9

Basic Principle of Wind Generation – Wind Data and Analysis - Principle of Wind Power Generation - Wind Site and its Resource Assessment - Wind Mills and Sub-Systems – Classification of Wind Turbines – Operating Characteristics of Wind-Mill – Wind Turbine Controls for Wind Power Plants (WPPs) : Stand-alone Mode – Grid Connected Wind Turbine Generator (GWTG) - Hybrid Systems – WPP Control Overview - Wind Power Plant (WPP) Control Strategies: FGS-FP, FGS-VP,VGS-FP and VGS-VP - Classification of Wind Power Plants (WPPs): Type-A WPP, Type-B WPP, Type-C WPP and Type-D WPP – Environmental Impact of Wind Energy

UNIT IV BIOENERGY 9

Biomass Resources - Biomass Conversion Technologies and their classification, Biogas Generation: Principle - Different Biogas Digesters: Floating Drum Type and Fixed Dome Type – Power Generation Systems using Biofuels: Power Generation from Biogas and Power Generation using Liquid Waste – Biomass Cogeneration Systems

UNIT V OTHER TYPES OF ENERGY 9

Energy Conversion from Hydrogen and Fuel cells, Introduction to Geothermal Energy - Mining of Geothermal Heat – Geothermal Field – Geothermal Resources – Environmental Impact from extracting Geothermal Energy - Geothermal potential in India – Ocean Thermal Energy Conversion Systems (OTEC): Historical Review – Principle - Different OTEC Systems – Details of OTEC Plant Components – Location and Environmental Impact of OTEC plants - Tidal Energy: Introduction – Working of the Tidal Plant -Layout of a typical Tidal Power House – Major problem associated with Tidal Plants – Wave Energy : Introduction – Wave and Wave Generation – Ocean Wave Parameters – Wave Energy Conversion Devices – Environmental Effects of Wave Energy

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Gain knowledge about the Renewable Energy (RE) Resource potential available in India as well as global RE scenario and need for RE Technology.

CO2: Understand the basics of Solar radiation, Solar Thermal Energy Conversion and SPV systems.

CO3: Understand the concepts of various Wind Energy Conversion System.

CO4: Gain knowledge about Bioenergy and Biomass Conversion Technologies.

CO5: Gain knowledge about energy conversion technologies for harnessing the energy from other RE resources such as Hydrogen, Fuel Cell, Geothermal, OTEC, Wave Energy and Tidal Energy.

REFERENCES:

1. Twidell and Wier," Renewable Energy Resources", CRC Press, 2010.
2. Tiwari and Ghosal," Renewable Energy Resources", Narosa Publishing India, 2015.
3. B.H.Khan, "Non – Conventional Energy Resources", Tata Mc Graw Hill, 2006.

Attested

4. V.M.Domkundwar, A.V.Domkundwar, “Solar Energy and Non-Conventional Energy Sources”, Dhanpat Rai & Co. Pvt. Ltd., India, 2018.
5. D.P.Kothari, K.C.Singhal, ”Renewable Energy Sources and Emerging Technologies”, Prentice Hall, India, 2015.
6. D.S.Chauhan, S.K. Srivastava, “Non – Conventional Energy Resources”, New Age Publishers, 2006.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	-	1	3
CO2	2	1	3	-	1	3
CO3	2	1	3	-	1	3
CO4	2	1	3	-	1	3
CO5	2	1	3	-	1	3
Average	**2**	**1**	**3**	**-**	**1**	**3**

PW3152 ENERGY CONSERVATION AND SUSTAINABLE DEVELOPMENT LT P C
3 0 0 3

UNIT I ENERGY CONSERVATION AND ENERGY EFFICIENCY IN ELECTRICAL SYSTEMS 9
Energy Conservation (EC): Importance of EC – Electrical System: Cascade Efficiency – Electricity Billing - Tariff Structure – Demand Curve - Power Factor (PF) and True Power Factor – Power Factor Correction Methods – Cost Benefits of PF Improvement –Performance Assessment of PF Capacitors – Demand Side Management (DSM).

UNIT II TRANSFORMERS AND MOTORS 9
Transformer: Basics - Types – Transformer Losses and Efficiency – Voltage Fluctuation Control: Off-Circuit Tap Changer and OLTC – Energy Efficient Transformers – Standards and Labelling for Distribution Transformers - Motors: Types - Characteristics – Efficiency - Motor selection – Factors affecting Energy Efficiency in Motors - Effects of rewinding – Need for Variable Frequency Drive (VFD) – Operating Principle of VFD - Energy Efficient (EE) Motors -– Star Labelling of EE Induction Motors.

UNIT III HVAC AND REFRIGERATION SYSTEM 9
Introduction – Types of Refrigeration system – Factors affecting performance and energy efficiency of refrigeration plants – Heat pumps and their applications – Ventilation systems - Standards and Labelling of room air conditioners – Energy saving opportunities.

UNIT IV LIGHTING SYSTEM 9
Introduction – Terms in Lighting System - Lamp types – Recommended Illuminance Levels – selection and application – ENCON opportunities – Energy Efficient Lighting Controls: Time Based Control –Occupancy Sensor.

UNIT V SUSTAINABLE DEVELOPMENT - CASE STUDIES 9
Introduction to Sustainable Development – Need for Sustainable Development – Importance of Sustainable Development – Pillars of Sustainable Development – Goals of Sustainable

Attested

Development – Global, Regional and Community initiatives for Sustainable Development – Need for CO_2 Mitigation— Introduction to PAT Scheme - Case Studies

TOTAL:45 PERIODS

COURSE OUTCOMES:

Upon the successful completion of the course, students will be able to:
CO1: Know the importance of Energy Conservation and Energy Efficiency in Electrical Systems.
CO2: Learn the various measures for energy conservation in transformers and motors.
CO3: Understand the energy efficiency in Refrigeration systems.
CO4: Design effective lighting systems.
CO5: Acquire the concept of goals towards Sustainable Development and PAT scheme.

REFERENCES:

1. Yacov Y. Haimes, Marguerite A. H Ruffner, "Energy Auditing and Conservation: Methods, Measurements, management and Case Studies", Taylor & Francis Inc, 1980.
2. "Energy Efficiency in Electrical Utilities", Third Edition, Bureau of Energy Efficiency (BEE), India, 2010.
3. Jack J. Kraushaar, Robert A. Ristenen, "Energy and Problems of a Technical Society", Second Edition, Wiley, 1993.
4. Detlef Stolten, Viktor Schere, "Transition to Renewable Energy Systems", First Edition, Wiley, 2013.
5. Charles M. Gottschalk, "Industrial Energy Conservation", First Edition, Wiley, 1996.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	2	-	1	2
CO2	2	1	2	-	1	2
CO3	2	1	2	-	1	2
CO4	2	1	2	-	1	2
CO5	2	1	2	-	1	2
Average	**2**	**1**	**2**	**-**	**1**	**2**

PE3151 ANALYSIS OF POWER CONVERTERS LT P C
3 0 0 3

UNIT I SINGLE PHASE AC-DC CONVERTER 9

Static Characteristics of power diode and SCR, half controlled and fully controlled converters with R-L, R-L-E loads and freewheeling diodes – continuous and discontinuous modes of operation - inverter operation –Sequence control of converters – performance parameters: harmonics, ripple, distortion, power factor – effect of source impedance and overlap-reactive power and power balance in converter circuits

UNIT II THREE PHASE AC-DC CONVERTER 9

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

UNIT III SINGLE PHASE INVERTERS 9

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

UNIT IV THREE PHASE INVERTERS 9

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

UNIT V MODERN INVERTERS 9

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

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

TEXT BOOKS:

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

Attested

REFERENCES:

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

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	2	3	2
CO2	2	2	2	2	3	2
CO3	2	1	2	1	3	1
CO4	2	2	2	2	3	1
CO5	2	2	2	2	3	2
Average	**2**	**1.8**	**2**	**1.8**	**3**	**1.6**

PE3053 POWER QUALITY **L T P C**
3 0 0 3

UNIT I INTRODUCTION 9

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

UNIT II ANALYSIS OF SINGLE PHASE AND THREE PHASE SYSTEM 9

Single phase linear and non-linear loads –single phase sinusoidal, non-sinusoidal source – supplying linear and non-linear load – three phase Balance system – three phase unbalanced system – three phase unbalanced and distorted source supplying non-linear loads – concept of PF – three phase three wire – three phase four wire system.

UNIT III CONVENTIONAL LOAD COMPENSATION METHODS 9

Principle of load compensation and voltage regulation – classical load balancing problem : open loop balancing – closed loop balancing, current balancing – harmonic reduction and voltage sag reduction– analysis of unbalance – instantaneous of real and reactive powers – Extraction of fundamental sequence component from measured.

UNIT IV LOAD COMPENSATION USING DSTATCOM 9

Compensating single – phase loads – Ideal three phase shunt compensator structure – generating reference currents using instantaneous PQ theory – Instantaneous symmetrical components theory – Generating reference currents when the source is unbalanced –Realization and control of DSTATCOM – DSTATCOM in Voltage control mode.

Attested

UNIT V SERIES COMPENSATION OF POWER DISTRIBUTION SYSTEM 9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

TEXTBOOKS:

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

REFERENCES:

1. R.C.Duggan Electric Power Systems Quality, Tata MC Graw Hill Publishers, Third Edition, 2012.
2. Arrillga Power System Harmonics, John Wiely and Sons, 2003 Second Edition.
3. Derek A.Paice Power Electronic Converter Harmonics, Wiley – IEE Press 1999, 18th Edition.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	1	1	2	-
CO2	3	-	2	1	1	-
CO3	3	1	3	3	-	-
CO4	3	-	3	3	-	-
CO5	3	1	1	2	3	-
Average	**2.8**	**1**	**2**	**2**	**2**	**-**

Attested

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HV3151 ELECTRICAL TRANSIENTS IN POWER SYSTEM L T P C
3 1 0 4

UNIT I LIGHTNING OVERVOLTAGES 9+3

Classification of overvoltages- Mechanism, parameters and characteristics of lightning strokes, protective shadow, striking distance, mathematical model for lightning, Grounding for protection against lightning — Steady state and dynamic tower-footing resistance, substation grounding Grid, Direct lightning strokes to overhead lines, without and with shield wires.

UNIT II SWITCHING AND TEMPORARY OVERVOLTAGES 9+3

Origin and characteristics of switching transients – double frequency transients – system performance under switching surges- Ferranti Effect, Temporary overvoltages – load rejection – line faults – ferroresonance, VFTO – Control of switching transients.

UNIT III TRAVELLING WAVES ON TRANSMISSION LINE 9+3

Circuits and distributed constants, wave equation, reflection and refraction at various transition points– behaviour of travelling waves at the line terminations – Lattice Diagrams – attenuation and distortion, lossless and distortionless lines – multiconductor system.

UNIT IV INSULATION CO-ORDINATION 9+3

Insulation co-ordination, Insulation strength and their selection- Evaluation of insulation strength standard BILs-Characteristics of protective devices, applications, location of arresters — insulation co-ordination in AIS and GIS.

UNIT V COMPUTATION OF POWER SYSTEM TRANSIENTS 9+3

Computation of transients using EMTP -Modelling of power system components- Simple case studies – Analysis of reflection and refraction waves at transition points and line terminations.

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

COURSEOUTCOMES:

CO1: Ability to understand generation of lightning overvoltages and importance of grounding
CO2: Ability to know about generation and control of switching and temporary overvoltages
CO3: Ability to predict overvoltages in power system using travelling wave theory
CO4: Ability to coordinate the insulation level of the power system
CO5: Ability to compute overvoltages using EMTP

REFERENCES

1. Pritindra Chowdhari, “Electromagnetic transients in Power System”, John Wiley and Sons Inc., Second Edition, 2008.
2. Allan Greenwood, “Electrical Transients in Power System”, Wiley & Sons Inc. New York, 2012.
3. Andrew R. Hileman, “Insulation Coordination for Power Systems”, CRC press, Taylor & Francis Group, New York, 1999.
4. Klaus Ragaller, “Surges in High Voltage Networks”, Plenum Press, New York, 1980.
5. Rakosh Das Begamudre, “Extra High Voltage AC Transmission Engineering”, (Second edition) Newage International (P) Ltd., New Delhi, 2014.
6. Naidu M S and Kamaraju V, “High Voltage Engineering”, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2020.

Attested

7. IEEE Guide for safety in AC substation grounding IEEE Standard 80-2000.
8. Working Group 33/13-09 (1988), 'Very fast transient phenomena associated with GasInsulated System', CIGRE, 33-13, pp. 1-20.
9. R. Ramanujam, "Computational Electromagnetic Transients: Modeling, Solution Methods andSimulation", I.K. International Publishing House Pvt. Ltd, New Delhi -110 016, 2019
10. Working Group WG 01 Guide to procedures for estimating the lightning performance of transmission lines, CIGRE 01-33, pp. 26-35.
11. Insulation Coordination Part 1 - Definition, Principles and Rules, IEC 60071 - 1, Edition 9.0, 2019-08
12. Hao Zhou et al, "Ultra-high Voltage AC/DC Power Transmission" ,Springer, 2018
13. Working Group C4.307, "Resonance and Ferro resonance in Power Networks", CIGRE 569, 88 – 97.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	1	1	1
CO2	3	2	2	1	1	1
CO3	3	2	2	1	1	1
CO4	3	1	2	1	1	3
CO5	3	1	1	3	1	1
Average	**3**	**1.6**	**1.8**	**1.4**	**1**	**1.4**

HV3051 DESIGN OF SUBSTATIONS **LT P C**
3 0 0 3

UNIT I INTRODUCTION TO AIS AND GIS 9

Introduction – characteristics – comparison of Air Insulated Substation (AIS) and Gas Insulated Substation (GIS) – main features of substations, Environmental considerations, Planning and installation- GIB / GIL

UNIT II MAJOR EQUIPMENT AND LAYOUT OF AIS AND GIS 9

Major equipment – design features – equipment specification, types of electrical stresses, mechanical aspects of substation design- substation switching schemes - single feeder circuits; single or main bus and sectionalized single bus- double main bus-main and transfer bus- main, reserve and transfer bus- breaker-and-a- half scheme-ring bus.

UNIT III INSULATION COORDINATION OF AIS AND GIS 9

Introduction – stress at the equipment – insulation strength and its selection – standard BILs – Application of simplified method – Comparison with IEEE and IEC standards.

UNIT IV GROUNDING AND SHIELDING 9

Definitions – soil resistivity measurement – ground fault currents – ground conductor – design of substation grounding system – shielding of substations – Shielding by ground wires and lightning masts.

Attested

UNIT V FAST TRANSIENTS PHENOMENON IN AIS AND GIS **9**

Introduction – origin of VFTO - Disconnector switching — propagation and mechanism of VFTO – VFTO characteristics – Effects of VFTO - Controlling methods

TOTAL : 45 PERIODS

COURSE OUTCOMES:

CO1 Ability to understand the fundamental components of AIS AND GIS.
CO2 Ability to understand the layout of AIS and GIS.
CO3 Ability to understand the insulation coordination of AIS and GIS.
CO4 Ability to understand the significance of grounding and shielding.
CO5 Ability to know about the effects of very fast transients in Substations

REFERENCES

1. Andrew R. Hileman, "Insulation coordination for power systems", Taylor and Francis, 1999.
2. M.S. Naidu, "Gas Insulation Substations", I.K. International Publishing House Private Limited, 2008.
3. Klaus Ragallar, "Surges in high voltage networks" Plenum Press,New York, 1980.
4. "Power Engineer's handbook", TNEB Association.
5. PritindraChowdhuri, "Electromagnetic transients in power systems", PHI Learning Private Limited, New Delhi, Second edition, 2008.
6. "Design guide for rural substation", United States Department of Agriculture, RUS Bulletin, 1724E-300, June 2001.
7. AIEE Committee Report, "Substation One-line Diagrams," AIEE Trans. on Power Apparatus and Systems, August 1953
8. Hermann Koch , "Gas Insulated Substations", Wiley-IEEE Press,2014
9. IEEE Std 80, IEEE Guide for Safety in AC Substation Grounding - 2013
10. IS Standard 3043 "CODE OF PRACTICE FOR EARTHING (First Revision)"; 1987.
11. Working Group JWG B3.35/CIRED, "Substation earthing system design optimisation through the application of quantified risk analysis" CIGRE 749,2018.
12. CIGRE Green Book, "Substation", Study Committee B3, PP 83 -155.
13. Working Group WG 23.03, "General guidelines for the design of outdoor AC substations. (2nd version)" CIGRE 161, 2000.

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	3	1	1	-	1
CO2	1	3	1	1	-	1
CO3	2	3	3	1	-	3
CO4	1	1	1	2	-	1
CO5	3	2	1	2	-	1
Average	**1.6**	**2.4**	**1.4**	**1.4**	**-**	**1.4**

MAPPING OF COs WITH POs

Mapped with 1, 2, 3 & -, scale : 1-low ; 2-medium ; 3-high ; ' - ' no correlation.

Attested

HV3153 INSULATION TECHNOLOGY L T P C
3 0 0 3

UNIT I PROPERTIES OF DIELECTRICS IN STATIC FIELDS 9
Static dielectric constant – Polarization and dielectric constant – atomic interpretation of the dielectric constant of mono-atomic gases –dependence of permittivity on various factors– internal field in solids and liquids.

UNIT II BEHAVIOR OF DIELECTRICS IN ALTERNATING FIELDS 9
Frequency dependence of the electronic polarizability – ionic polarization as a function of frequency – complex dielectric constant of non-dipolar solids – dipolar relaxation – dielectric losses.

UNIT III BREAKDOWN MECHANISMS IN GASEOUS DIELECTRICS 9
Behavior of gaseous dielectrics in electric fields – gaseous discharges – different ionization processes – effect of electrodes on gaseous discharge – Townsend's theory, Streamer theory – electronegative gases, gaseous discharges in non-uniform fields – alternate Green gases and mixture of gases- breakdown in vacuum insulation.

UNIT IV BREAKDOWN MECHANISMS IN SOLID AND LIQUID DIELECTRICS 9
Solid Dielectrics-Intrinsic breakdown of solid dielectrics – electromechanical breakdown-Streamer breakdown, thermal breakdown - electrochemical breakdown – tracking and treeing – thermal and electrical ageing and partial discharges - classification of solid dielectrics, composite insulation. Liquids dielectrics- conduction and breakdown in pure ,commercial liquids and Biodegradable oils.

UNIT V APPLICATION OF INSULATING MATERIALS 9
Application of insulating materials in power equipment and recent advancements-environment friendly and recyclable insulation.

TOTAL : 45 PERIODS

COURSE OUTCOMES:
CO1 Ability to understand the fundamental behavior of dielectrics in static fields.
CO2 Ability to understand the fundamental behavior of dielectrics in alternating fields.
CO3 To understand the performance of gaseous dielectrics.
CO4 Ability to understand the behavior of liquid and solid dielectrics
CO5 Ability to select the suitable insulation for an electrical power equipment

REFERENCES

1. Thermal Insulation and Radiation Control Technologies for Buildings - Jankosny, David W. Yarbrough - Springer - 2022.
2. M.S Naidu, V.Kamaraj, "High Voltage Engineering", Tata Mc Graw-Hill Publishing Company Ltd., New Delhi, 6th Edition 2020.
3. Alston, L.L, "High Voltage Technology", Oxford University Press, London, 1968 (B.S Publications, Second Indian Edition 2008).
4. Introduction to Polarization Physics – Sandibek B. Nurushev, Mikhail F. Runtso, Mikhail N. Strikhanov - Sripnger - 2013
5. Adrinaus, J.Dekker, "Electrical Engineering Materials", Prentice Hall of India Pvt. Ltd., New Delhi, 1959.
6. Dieter Kind and Hermann Karner, "High Voltage Insulation Technology", 1985. (Translated from German by Y. Narayana Rao, Friedr. Vieweg & Sohn, Braunschweig).
7. Kuffel, E., Zaengl, W.S. and Kuffel J., "High Voltage Engineering Fundamentals", Elsvier India Pvt. Ltd, 2005
8. V.Y.Ushakov, "Insulation of High Voltage Equipment", Springer ISBN.3-540-20729-5, 2004.
9. R.E.james and Q.Su,"Condition Assessment of High Voltage Insulation in Power System Equipment", IET publications,London,U.K,2008

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	3	3	2
CO2	3	2	3	3	3	2
CO3	3	2	3	2	3	3
CO4	3	2	3	2	3	3
CO5	3	3	3	3	3	3
Average	**3**	**2.2**	**3**	**2.6**	**3**	**2.6**

CO3152 INTELLIGENT CONTROLLERS LT P C
3 0 0 3

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

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

UNIT II NEURAL NETWORKS FOR MODELLING AND CONTROL 9

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

UNIT III FUZZY LOGIC FOR MODELLING AND CONTROL 9

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

UNIT IV GENETIC ALGORITHM 9

Basic concept of Genetic algorithm and detail algorithmic steps, adjustment of free parameters. Solution of typical control problems using genetic algorithm. Concept on some other search techniques Firefly algorithm, Differential Evolution and Particle Swarm Optimization.

UNIT V HYBRID CONTROL SCHEMES 9

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

TOTAL: 45 PERIODS

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

CO1 : Understand the basic architectures of NN and Fuzzy sets
CO2 : Design and implement ANN architectures, algorithms and know their limitations.

CO3 : Identify and work with different operations on the fuzzy sets.
CO4 : Develop ANN and fuzzy logic based models and control schemes for non-linearsystems.
CO5 : Understand and explore hybrid control schemes and PSO

REFERENCES:

1. LaureneV.Fausett, “Fundamentals of Neural Networks, Architecture, Algorithms, and Applications”, Pearson Education, 2008.
2. Timothy J Ross, “Fuzzy Logic With Engineering Applications” VISIONIAS, Third Edition,2020.
3. David E.Goldberg, “Genetic Algorithms in Search, Optimization, and Machine Learning”, Pearson Education, 2009.
4. W.T. Miller, R.S.Sutton and P.J.Webrose, “Neural Networks for Control”, MIT Press, 1996
5. George J.Klir and Bo Yuan, “Fuzzy Sets & Fuzzy Logic Theory And Applications” VISIONIAS, 2020.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	2	1	-	-	-
CO2	-	2	1	-	-	-
CO3	-	1	-	-	-	-
CO4	3	2	-	2	-	-
CO5	-	1	-	1	1	3
Average	3	1.6	1	1.5	1	3

Note: 1-low, 2-medium, 3-high, ‘-“- no correlation

ET3054 EMBEDDED CONTROLLERS FOR EV APPLICATIONS LT P C
3 0 0 3

UNIT I EMBEDDED SYSTEM AND ELECTRIC VEHICLES ARCHITECTURE 9

Overview of Electric vehicles - Evolution of Electric Vehicles - Definition and types of EV (BEV, HEV, PHEV) - EV Architecture - EV Components and Subsystems - Advantages and challenges of EV - Comparison of EV with Internal Combustion Engine - Emerging trends in EV Technologies- Embedded System Architecture- Open ECU-AUTOSAR.

UNIT II POWERTRAIN CONTROL AND ENERGY MANAGEMENT SYSTEM IN EV 9

Powertrain Components - Powertrain control and Optimization - Embedded Controllers for motor control- ECU for Energy Management system - Battery Management System (BMS) - Battery State of Charge (SoC) Estimation - Energy Consumption Monitoring - Charging Optimization- ECU for Charging.

UNIT III COMMUNICATION AND CONNECTIVITY IN EV 9

Vehicle-to-Vehicle Technology(V2V) - Vehicle-to-Infrastructure(V2I) Technology Communication - Communication Protocol (CAN, LIN, Ethernet, etc.) - Wireless Charging and Communication for EV - Over the air (OTA) Updates and Remote diagnostics in EV.

UNIT IV FAULT MONITORING AND DIAGNOSTICS IN EV 9

Overview of Fault Monitoring and Diagnostics in EV - Fault detection techniques - Fault Monitoring in Electric Powertrain - Fault Monitoring in Charging Infrastructure - On-board Diagnostics (OBD) with self-check mechanisms - Diagnostics and Reporting - Case studies on fault detection, Diagnosis and Resolution

UNIT V SAFETY, SECURITY AND AUTONOMOUS SYSTEMS IN EV 9

Safety Standards and Regulations for EVs - Functional Safety and ISO26262 in EV -Cybersecurity in EVs - Threats and Countermeasures - Antilock Braking system(ABS) -Electronic Stability Control (ESC) - Advanced driver Assistance systems (ADAS) -Autonomous Driving in EVs.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Able to understand the principles and components of electric vehicles, including powertrain systems, energy storage systems, motor controllers, and vehicle dynamics.

CO2: Able to learn about the unique requirements and challenges associated with embedded controllers in EV applications.

CO3: able to learn about hardware platforms, such as microcontrollers and microprocessors, as well as communication protocols and interfaces used for control and monitoring of EV.

CO4: Able to gain hands-on experience in developing embedded control algorithms for various EV systems, including motor control, battery management, regenerative braking, and charging systems.

CO5: able to understand the integration of embedded controllers in autonomous electric vehicles

REFERENCES:

1."Embedded Control Systems for Electric Machines" by Jiming Wang, Shan Chai, and Shuxin Zhou (Published in 2011)

2."Electric and Hybrid Vehicles: Design Fundamentals" by Iqbal Husain (Published in 2013)

3."Electric and Hybrid Vehicles: Power Sources, Models, Sustainability, Infrastructure, and the Market" by Gérard-André Capolino (Published in 2010)

4."Embedded Systems for Electric Vehicles" by Jürgen Valldorf and Wolfgang Gessner (Published in 2011)

5."Power Electronics and Electric Drives for Traction Applications" by Gonzalo Abad, J. Miguel Guerrero, and Juan de la Casa (Published in 2016)

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	3	3
CO2	3	-	-	-	-	-
CO3	3	-	-	-	-	3
CO4	3	3	3	3	3	3
CO5	2	3	3	3	3	3
Average	**2.8**	**3**	**3**	**3**	**3**	**3**

Attested

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ET3062 **MEMS AND NEMS TECHNOLOGY** **LT P C**
3 0 0 3

UNIT I INTRODUCTION TO MEMS and NEMS 9
Overview of micro and Nano technologies - Miniaturization significance and advantages -Micro electro mechanical systems and Nano Electro mechanical systems, devices and technologies, Laws of scaling - Survey of materials - Smart Sensors - Applications of MEMS and NEMS.

UNIT II MICRO-MACHINING AND MICROFABRICATION TECHNIQUES 9
Photolithography - material Synthesis techniques - Film deposition - Etching Processes- wafer bonding - Bulk micro machining, silicon surface micro machining - LIGA process.

UNIT III MICRO SENSORS AND MICRO ACTUATORS 9
Transduction mechanisms in different energy domain-Micromachined capacitive, Piezoelectric, piezoresistive and Electromechanical and thermal sensors/actuators and applications

UNIT IV NANOELECTRONICS DEVICES AND NEMS TECHNOLOGY 9
Nano electronics devices and applications – SET– RTD – Memristor – QCA - molecular Electronics - Nano Fabrication techniques - atomic scale precision Engineering- NEMS in measurement, sensing, actuation and systems design.

UNIT V MEMS AND NEMS APPLICATION 9
Micro/Nano Fluids and applications- Bio MEMS- Optical NEMS- Micro and Nano motors-Quantum computing.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
At the end of this course, the students will have the ability to
CO1: Explain the material properties and the significance of MEMS and NEMS for industrial automation.
CO2: Demonstrate knowledge delivery on micromachining and micro fabrication.
CO3: Apply the fabrication mechanism for MEMS sensor and actuators.
CO4: Apply the concepts of Nano electronics and NEMS to models, simulate and process the sensors and actuators.
CO5: Improved Employability and entrepreneurship capacity due to knowledge up gradation on MEMS and NEMS technology.

REFERENCES:

1. Chang Liu, “Foundations of MEMS”, Pearson International Edition, 2006.
2. Marc F madou “Fundamentals of micro fabrication” CRC Press 2002 2nd Edition Marc Madou.
3. M.H.Bao “Micromechanical transducers :Pressure sensors, accelerometers and gyroscopes”,Elsevier, Newyork, 2000.
4. Maluf, Nadim “An introduction to Micro Electro-mechanical Systems Engineering” AR Tech house, Boston 2000.
5. Mohamed Gad - el - Hak “MEMS Handbook” Edited CRC Press 2002 2. Sabriesolomon “Sensors Handbook”, Mc Graw Hill 1998.
6. Tai-Ran Hsu, “MEMS and Microsystems: design, manufacture, and Nanoscale”- 2nd Edition, John Wiley & Sons, Inc., Hoboken, New Jersey, 2008
7. Lyshevski, S.E. “Nano- and Micro-Electromechanical Systems: Fundamentals of Nano-and Microengineering “(2nd ed.). CRC Press,2005.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	-	2	-
CO2	3	3	2	-	2	2
CO3	3	3	3	-	2	2
CO4	3	3	3	-	3	2
CO5	3	2	3	2	3	3
Average	**3**	**2.6**	**2.8**	**2**	**2.4**	**2.25**

ET3065 ROBOTICS AND AUTOMATION LT P C
3 0 0 3

UNIT I INTRODUCTION TO ROBOTICS & AUTOMATION 9
Overview of Robotics & Automation - Principles and Strategies of Automation System -Hardware and software for Automation - Embedded Processors for Automation-Different Types of Robots - Various Generations of Robots - Asimov's Laws Of Robotics - Key components of a robot - Design Criteria for Selection of a Robot - Role of embedded system in Robotics and Automation - Recent trends.

UNIT II SENSORS AND DRIVE SYSTEMS 9
Hydraulic, Pneumatic And Electric Drive Systems - Understanding how motor power, current torque, friction co-efficient affect the design of a Robot - Determination of Motor HP and Gearing Ratio - Variable Speed Arrangements. Sensors - Classification based on sensing type (including Optical, Acoustic, Magnetic) - Proximity Sensors - Ranging Sensors - Speed & Displacement Sensing - Tactile Sensors - Vision Sensing - Smart Sensors - MEMS sensors.

UNIT III MANIPULATORS AND GRIPPERS 9
Introduction to Manipulators - Joints and Degrees of Freedom - Construction of Manipulators - Manipulator Dynamics and Force Control - Electronic And Pneumatic Manipulator Control Circuits - End Effectors - Various Types Of Grippers - Design Considerations.

UNIT IV KINEMATICS AND PATH PLANNING 9
Kinematic Equations - Forward and Inverse Kinematics - Solution Of Inverse Kinematics Problem - Jacobian based Velocity Kinematics- Various Path Planning Algorithms - Hill Climbing Techniques - Robot Operating System - Simulation and modeling of a simple Path Planning application.

UNIT V CASE STUDIES 9
Robot Cell Design - Humanoid Robot - Robots in healthcare applications - Robot Machine Interface - Robots in Manufacturing and Non-Manufacturing Applications - Self balancing robots - Micro/nano robots.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
At the end of this course, the students will have the ability to
CO1: Choose suitable embedded boards for robots
CO2: Demonstrate the concepts of robotics & automation and Working of Robot
CO3: Analyze the Function of Sensors and actuators In the Robot
CO4: Develop Program to Use a Robot for a Typical Application
CO5: Apply and improve Employability and entrepreneurship capacity due to knowledge upgradation on Embedded system-based robot development

Attested

REFERENCES:
1. Mikell P. Weiss G.M., Nagel R.N., Odraj N.G., “Industrial Robotics”, Mc Graw-Hill Singapore, 1996.
2. Ghosh, Control in Robotics and Automation: Sensor Based Integration, Allied Publishers, Chennai, 1998.
3. Deb. S.R., “Robotics Technology And Flexible Automation”, John Wiley, USA 1992.
4. Klafter R.D.,Chimielewski T.A., Negin M., “Robotic Engineering - An Integrated Approach”, Prentice Hall of India, New Delhi, 1994.
5. Mc Kerrow P.J. “Introduction to Robotics”, Addison Wesley, USA, 1991.
6. Issac Asimov “Robot”, Ballantine Books, New York, 1986.
7. Barry Leatham - Jones, “Elements of Industrial Robotics” PITMAN Publishing, 1987.
8. MikellP.Groover, Mitchell Weiss, Roger N.Nagel Nicholas G.Odrey, “Industrial Robotics Technology, Programming And Applications “, McGraw Hill Book Company 1986.
9. Fu K.S. Gonzaleaz R.C. And Lee C.S.G., “Robotics Control Sensing, Vision and Intelligence” McGraw Hill International Editions, 1987

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	-	3	-	-
CO2	-	3	-	-	-	-
CO3	-	-	-	-	-	-
CO4	-	-	-	2	3	1
CO5	-	-	2	1	-	3
Average	**1**	**2.5**	**2**	**2**	**3**	**2**

ET3059 INTELLIGENT SYSTEM DESIGN LT P C
3 0 0 3

UNIT I INTELLIGENT SYSTEMS AND PYTHON PROGRAMMING 9
Introduction to Machine Learning and Deep Learning - Performance Improvement with Machine Learning - Building Intelligent Systems - Introduction to Python -Python Programming

UNIT II PYTHON FOR ML 9
Python Application of Linear Regression and Polynomial Regression using SciPy - Interpolation, Overfitting and Underfitting concepts & examples using SciPy - Clustering and Classification using Python.

UNIT III EMERGING TRENDS IN HARDWARE ARCHITECTURES FOR DEEP LEARNING 9
Quantization and Precision Reduction Techniques - Hardware aware neural Architecture. Hardware-software co-design for deep learning systems Memory hierarchy and cache optimization for deep learning Parallelization and distributed training of deep learning models Energy-efficient deep learning hardware architectures Hardware acceleration for specific deep learning applications (e.g., natural language processing, computer vision)

UNIT IV PYTHON FOR DL 9
Python Applications for DL - Python for CNN and YOLO

UNIT V CASE STUDIES 9
Development of Intelligent System for Power system protection - Smart Energy - IOE- Motor control - BMS - Intelligent systems for Industry 4.0 and Industry 5.0

Attested

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Able to gain proficiency in the Python programming language and learn how to apply it in the context of intelligent systems

CO2: Able to learn Python libraries such as NumPy, Pandas, and scikit-learn to preprocess data, build and train Machine Learning models, and evaluate their performance

CO3: Able to learn Deep Learning libraries such as TensorFlow or PyTorch to build, train, and evaluate Deep Learning models for tasks such as image classification, natural language processing, and computer vision.

CO4: Able to learn hardware components, such as processors, memory, and accelerators, and how they are integrated.

CO5: Able to learn intelligent systems implementations, examine their design choices, evaluate their performance, and understand the challenges.

REFERENCES:

1."Intelligent Systems: Principles, Paradigms, and Pragmatics" by Rajendra P. Srivastava (Published in 2013)

2."Intelligent Systems: A Modern Approach" by Thomas Bäck, David B. Fogel, and Zbigniew Michalewicz (Published in 2000)

3."Intelligent Systems: Modeling, Optimization, and Control" by Grzegorz Bocewicz and Konrad Jackowski (Published in 2016)

4."Intelligent Systems: Architecture, Design, and Control" by Janos Sztipanovits and Gabor Karsai (Published in 2018)

5."Intelligent Systems: Concepts and Applications" by Veera M. Boddu (Published in 2017)

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	3	3
CO2	3	-	-	-	-	-
CO3	3	-	-	-	-	3
CO4	3	3	3	3	3	3
CO5	2	3	3	3	3	3
Average	**2.8**	**3**	**3**	**3**	**3**	**3**

ET3052 BLOCKCHAIN TECHNOLOGIES

L T P C
3 0 0 3

UNIT I INTRODUCTION OF CRYPTOGRAPHY AND BLOCKCHAIN 9

Introduction to Blockchain, Blockchain Technology Mechanisms & Networks, Blockchain Origins, Objective of Blockchain, Blockchain Challenges, Transactions and Blocks, P2P Systems, Keys as Identity, Digital Signatures, Hashing, and public key cryptosystems, private vs. public Blockchain-Hardware architecture for Blockchain.

UNIT II BITCOIN AND CRYPTOCURRENCY 9

Introduction to Bitcoin, The Bitcoin Network, The Bitcoin Mining Process, Mining Developments, Bitcoin Wallets, Decentralization and Hard Forks, Ethereum Virtual Machine (EVM), Merkle Tree, Double-Spend Problem, Blockchain and Digital Currency, Transactional Blocks, Impact of Blockchain Technology on Cryptocurrency.

Attested

UNIT III INTRODUCTION TO ETHEREUM **9**

Introduction to Ethereum, Consensus Mechanisms, Metamask Setup, Ethereum Accounts, , Transactions, Receiving Ethers, Smart Contracts.

UNIT IV INTRODUCTION TO HYPERLEDGER AND SOLIDITY PROGRAMMING **10**

Introduction to Hyperledger, Distributed Ledger Technology & its Challenges, Hyperledger & Distributed Ledger Technology, Hyperledger Fabric, Hyperledger Composer. Solidity - Language of Smart Contracts, Installing Solidity & Ethereum Wallet, Basics of Solidity, Layout of a Solidity Source File & Structure of Smart Contracts, General Value Types.

UNIT V BLOCKCHAIN APPLICATIONS **8**

Internet of Things, Medical Record Management System, Domain Name Service and Future of Blockchain, Alt Coins.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Understand and explore the working of Blockchain technology

CO2: Analyze the working of Smart Contracts

CO3: Understand and analyze the working of Hyperledger

CO4: Apply the learning of solidity to build de-centralized apps on Ethereum

CO5: Develop applications on Blockchain

REFERENCES:

1. Imran Bashir, “Mastering Blockchain: Distributed Ledger Technology, Decentralization, and Smart Contracts Explained”, Second Edition, Packt Publishing, 2018.
2. Narayanan, J. Bonneau, E. Felten, A. Miller, S. Goldfeder, “Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction” Princeton University Press, 2016
3. Antonopoulos, Mastering Bitcoin, O’Reilly Publishing, 2014. .
4. Antonopoulos and G. Wood, “Mastering Ethereum: Building Smart Contracts and Dapps”, O’Reilly Publishing, 2018.
5. D. Drescher, Blockchain Basics. Apress, 2017.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	-	2	-	-	-
CO2	1	-	3	2	-	-
CO3	-	-	1	3	1	-
CO4	1	-	-	1	2	-
CO5	-	-	2	-	-	-
Average	**1**	**-**	**2**	**2**	**1.5**	**-**

Attested

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ET3051 BIG DATA ANALYTICS L T P C
3 0 0 3

UNIT I INTRODUCTION TO BIG DATA 9

Introduction to Big Data Platform - Challenges of Conventional Systems - Intelligent data analysis - Nature of Data - Analytic Processes and Tools - Analysis Vs Reporting - Modern Data Analytic Tools- Statistical Concepts: Sampling Distributions - Re-Sampling - Statistical Inference - Prediction Error.

UNIT II SEARCH METHODS AND VISUALIZATION 9

Search by simulated Annealing - Stochastic, Adaptive search by Evaluation - Evaluation Strategies - Genetic Algorithm - Genetic Programming - Visualization - Classification of Visual Data Analysis Techniques - Data Types - Visualization Techniques - Interaction techniques - Specific Visual data analysis Techniques

UNIT III MINING DATA STREAMS 9

Introduction To Streams Concepts - Stream Data Model and Architecture - Stream Computing - Sampling Data in a Stream - Filtering Streams - Counting Distinct Elements in a Stream - Estimating Moments - Counting Oneness in a Window - Decaying Window - Real time Analytics Platform (RTAP) Applications - Case Studies - Real Time Sentiment Analysis, Stock Market Predictions

UNIT IV FRAMEWORKS 9

MapReduce - Hadoop, Hive, MapR - Sharding - NoSQL Databases - S3 - Hadoop Distributed File Systems - Case Study - Preventing Private Information Inference Attacks on Social Networks - Grand Challenge: Applying Regulatory Science and Big Data to Improve Medical Device Innovation

UNIT V R LANGUAGE 9

Overview, Programming structures: Control statements - Operators -Functions - Environment and scope issues - Recursion - Replacement functions, R data structures: Vectors - Matrices and arrays - Lists - Data frames - Classes, Input/output, String manipulations

TOTAL:45 PERIODS

COURSE OUTCOMES:

CO1: Understand the basics of big data analytics
CO2: Ability to use Hadoop, Map Reduce Framework.
CO3: Ability to identify the areas for applying big data analytics for increasing the business outcome.
CO4: Gain knowledge on R language
CO5: Contextually integrate and correlate large amounts of information to gain faster insights.

REFERENCES:

1. Michael Berthold, David J. Hand, Intelligent Data Analysis, Springer, 2007.
2. Anand Rajaraman and Jeffrey David Ullman, Mining of Massive Datasets, Cambridge University Press, 3rd edition 2020.
3. Norman Matloff, The Art of R Programming: A Tour of Statistical Software Design, No Starch Press, USA, 2011.
4. Bill Franks, Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics, John Wiley & sons, 2012.
5. Glenn J. Myatt, Making Sense of Data, John Wiley & Sons, 2007.

Attested

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MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	-	2	-	-	-
CO2	1	-	3	2	-	-
CO3	-	-	1	3	1	-
CO4	1	-	-	1	2	-
CO5	-	-	2	-	-	-
Average	**1**	**-**	**2**	**2**	**1.5**	**-**

ET3061 MACHINE LEARNING AND DEEP LEARNING **LT P C**
3 0 0 3

UNIT I LEARNING PROBLEMS AND ALGORITHMS 9
Various paradigms of learning problems, Supervised, Semi-supervised and Unsupervised algorithms

UNIT II NEURAL NETWORKS 9
Differences between Biological and Artificial Neural Networks - Typical Architecture, Common Activation Functions, Multi-layer neural network, Linear Separability, Hebb Net, Perceptron, Adaline, Standard Back propagation Training Algorithms for Pattern Association - Hebb rule and Delta rule, Hetero associative, auto associative, Kohonen Self Organising Maps, Examples of Feature Maps, Learning Vector Quantization, Gradient descent, Boltzmann Machine Learning.

UNIT III MACHINE LEARNING - FUNDAMENTALS & FEATURE SELECTIONS & CLASSIFICATIONS 9
Classifying Samples: The confusion matrix, Accuracy, Precision, Recall, F1 - Score, the curse of dimensionality, training, testing, validation, cross validation, overfitting, under-fitting the data, early stopping, regularization, bias and variance. Feature Selection, normalization, dimensionality reduction, Classifiers: KNN, SVM, Decision trees, Naïve Bayes, Binary classification, rain forest algorithm-multi class classification, clustering.

UNIT IV DEEP LEARNING: CONVOLUTIONAL NEURAL NETWORKS 9
Feed forward networks, Activation functions, back propagation in CNN, optimizers, batch normalization, convolution layers, pooling layers, fully connected layers, dropout, case study based on CNNs.

UNIT V DEEP LEARNING: RNNS, AUTOENCODERS AND GANS 9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES (CO):
At the end of the course the student will be able to
CO1: Illustrate the categorization of machine learning algorithms.
CO2: Compare and contrast the types of neural network architectures, activation functions
CO3: Acquaint with the pattern association using neural networks
CO4: Elaborate various terminologies related with pattern recognition and architectures of convolutional neural networks

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

REFERENCES:

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

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	3	1	-	-	-
CO2	2	3	2	-	-	-
CO3	3	-	3	-	3	-
CO4	2	3	3	-	-	-
CO5	3	3	3	-	3	-
Average	**2.2**	**3**	**2.4**	**-**	**3**	**-**