PAAVAI ENGINEERING COLLEGE, NAMAKKAL – 637018
(AUTONOMOUS)
M.E. POWER SYSTEMS ENGINEERING
REGULATIONS 2023
(CHOICE BASED CREDIT SYSTEM)
(Applicable to the students admitted for the academic year 2023-2024 onwards)
CURRICULUM

SEMESTER I							
S.No	**Category**	**Course Code**	**Course Title**	**L**	**T**	**P**	**C**
Theory							
1	PC	PPS23101	Advanced Power System Analysis	3	1	0	4
2	PC	PPS23102	Power System Dynamics	3	1	0	4
3	PC	PPS23103	Power System Transients	3	0	0	3
4	PC	PPS23104	Power System Instrumentation	3	0	0	3
5	FC	PEN23101	Research Methodology and IPR	3	0	0	3
6	PE	PPS2315*	Professional Elective I	3	0	0	3
7	AC	PAC23101	English for Research Paper Writing (Audit Course I)	2	0	0	0
Practical							
8	PC	PPS23105	Advanced Power System Simulation Laboratory I	0	0	4	2
			TOTAL	**20**	**2**	**4**	**22**
SEMESTER II							
S.No	**Category**	**Course Code**	**Course Title**	**L**	**T**	**P**	**C**
Theory							
1	PC	PPS23201	Restructured Power Systems	3	1	0	4
2	PC	PPS23202	Advanced Power System Protection	3	1	0	4
3	PC	PPS23203	Smart Grid	3	0	0	3
4	PC	PPS23204	Power System State Estimation and Security Assessment	3	0	0	3
5	PE	PPS2315*	Professional Elective II	3	0	0	3
6	PE	PPS2315*	Professional Elective III	3	0	0	3
7	AC	PAC23201	Pedagogy Studies (Audit Course II)	2	0	0	0
Practical							
8	PC	PPS23205	Advanced Power System Simulation Laboratory II	0	0	4	2
			TOTAL	**20**	**2**	**4**	**22**

SEMESTER III							
S.No	Category	Course Code	Course Title	L	T	P	C
Theory							
1	PC	PPS23301	Electrical Power Distribution System	3	0	0	3
2	PE	PPS2315*	Professional Elective IV	3	0	0	3
3	OE	********	Open Elective	3	0	0	3
Practical							
4	EE	PPS23302	Project Phase I	0	0	12	6
			TOTAL	**9**	**0**	**12**	**15**

SEMESTER IV							
S.No	Category	Course Code	Course Title	L	T	P	C
Practical							
1	EE	PPS23401	Project Phase II	0	0	24	12
			TOTAL	**0**	**0**	**24**	**12**

LIST OF PROFESSIONAL ELECTIVES							
S.No	Category	Course Code	Course Title	L	T	P	C
1	PE	PPS23151	Analysis of Power Converters	3	0	0	3
2	PE	PPS23152	System Theory	3	0	0	3
3	PE	PPS23153	Power System Reliability	3	0	0	3
4	PE	PPS23154	Design of Substation	3	0	0	3
5	PE	PPS23155	Analysis of Electrical Machines	3	0	0	3
6	PE	PPS23156	IoT for Smart Systems	3	0	0	3
7	PE	PPS23157	Power Electronics Application to Wind and Solar Energy Systems	3	0	0	3
8	PE	PPS23158	Solar and Energy Storage Systems	3	0	0	3
9	PE	PPS23159	Python for Power Systems Engineering	3	0	0	3
10	PE	PPS23160	Electromagnetic Interference and Compatibility in System Design	3	0	0	3
11	PE	PPS23161	Power Quality	3	0	0	3
12	PE	PPS23162	Application of DSP to Power System Protection	3	0	0	3
13	PE	PPS23163	SCADA System and Application	3	0	0	3
14	PE	PPS23164	FACTS and Custom Power Devices	3	0	0	3
15	PE	PPS23165	Computer Relaying and Wide Area Measurement Systems	3	0	0	3
16	PE	PPS23166	Energy Management and Auditing	3	0	0	3

LIST OF OPEN ELECTIVES							
S.No	**Category**	**Course Code**	**Course Title**	**L**	**T**	**P**	**C**
1	OE	PSE23901	Climate Change and Adaptation	3	0	0	3
2	OE	PED23901	Industrial Safety	3	0	0	3
3	OE	PCS23901	Design of Digital System	3	0	0	3
4	OE	PCE23901	Big Data Analytics	3	0	0	3
5	OE	PPS23901	Alternate Energy Sources	3	0	0	3

SEMESTER I

PPS23101 **ADVANCED POWER SYSTEM ANALYSIS** **3 1 0 4**

COURSE OBJECTIVES

To enable the students to

- know about solution techniques.
- understand load flow analysis.
- know the concept of optimal power flow analysis.
- realize contingency analysis for short circuit studies.
- comprehend transient stability analysis.

UNIT I SOLUTION TECHNIQUE **12**

Sparse matrix techniques for large-scale power systems; Optimally ordered triangular; Triangular decomposition- Gaussian elimination; Triangular decomposition of table of factors; Bi-factorization method; Sparsity and optimal ordering scheme.

UNIT II LOAD FLOW ANALYSIS **12**

Fast decoupled load flow method; Contingency analysis - Overview of security analysis, Linear sensitivity factors; AC power flow security analysis – Flowchart; AC power flow security analysis with contingency case selection; Principles of available transfer capability(ATC) determination; Methods of static ATC determination - ATC determination using multiple load flow and continuation power flow, optimization based method, ATC determination using linear sensitivity factors; ATC determination considering the effect of contingency analysis.

UNIT III OPTIMAL POWER FLOW (OPF) ANALYSIS **12**

OPF Formulation- Economic load dispatch, optimal reactive power dispatch, economic emission dispatch, security constrained OPF; OPF solution technique- Lagrange multiplier method, linear programming OPF, interior point method; Unit commitment - Objective function, constraints in unit commitment; unit commitment solution methods- Priority list method, dynamic programming method.

UNIT IV SHORT CIRCUIT ANALYSIS **12**

Thevenin's theorem and Z bus; Z bus methods in contingency analysis- Adding and removing multiple lines, piecewise solution of interconnected systems, analysis of single contingencies, analysis of multiple contingencies, contingency analysis by De-model, system reduction for contingency and fault studies.

UNIT V TRANSIENT STABILITY ANALYSIS **12**

Assumptions of transient stability analysis; Multimachine transient stability- Mathematical model of multimachine transient stability analysis; Factors influencing transient stability; Techniques for transient stability improvement; Mathematical representation for use in transient stability simulation-

Mathematical definitions of stability, mathematical models for transient stability simulation; Simulation methods- Partitioned explicit, implicit integration.

TOTAL PERIODS 60

COURSE OUTCOMES

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

- explain about solution techniques.
- describe the techniques in load flow analysis.
- implement the concept of optimal power flow analysis in real time application.
- enumerate contingency analysis for short circuit studies.
- explain transient stability analysis.

REFERENCES

1. P.Venkatesh, B.V.Manikandna, S.Charles Raja, A.Srinivasan, "Electrical Power Systems Analysis, Security and Deregulation", PHI Learning Private Limited., New Delhi, Second Edition, 2017.
2. D P Kothari, I J Nagrath, "Modern Power System Analysis", Tata McGraw Hill Education Private Limited., New Delhi, Fifth Edition, 2022.
3. John J. Grainger, William D. Stevenson, Jr., "Power System Analysis", Tata McGraw Hill Education Private Limited., New Delhi, 27th Edition, Reprint 2017.
4. M. A. Pai Dheeman Chatterjee, "Computer Techniques in Power System Analysis", McGraw-Hill Education India 2014.

CO-PO MAPPING

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	Programme Outcomes PO's												PSO's	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	3	2	2	-	-	-	-	-	-	2	3	3	3
CO2	3	3	2	2	-	-	-	-	-	-	2	3	3	3
CO3	3	3	2	2	-	-	-	-	-	-	2	3	3	3
CO4	3	3	3	1	-	-	-	-	-	-	2	3	3	3
CO5	3	3	2	1	3	-	-	-	-	-	2	3	3	3

PPS23102 POWER SYSTEM DYNAMICS 3 1 0 4

COURSE OBJECTIVES

To enable the students to

- impart knowledge on dynamic modeling of a synchronous machine in detail.
- describe the modeling of excitation.
- understand and enhance small signal stability problem of power systems.
- understand the fundamental concepts of transient stability of dynamic systems.
- model the power system components in voltage stability studies.

UNIT I SYNCHRONOUS MACHINE AND MODELLING 12

Physical description; Mathematical description of a synchronous machine - Basic equations of a synchronous machine, stator circuit equations, stator self-inductances, stator mutual inductances and stator to rotor mutual inductances; dq0 transformation; Per unit representation; Equivalent circuits for direct and quadrature axes; Steady-state analysis; Equations of motion - Swing equation, H-constant calculation, representation in system studies.

UNIT II EXCITATION SYSTEM MODELLING 12

Elements of an excitation system; Types of excitation system; Dynamic performance measure; Control and protective functions; Modelling of excitation system.

UNIT III SMALL SIGNAL STABILITY 12

Fundamental concept of stability of dynamic system; Eigen properties of the state matrix; Small signal stability of a single machine infinite bus system; Effects of excitation system; Power system stabilizer; Small signal stability of multi machine system.

UNIT IV TRANSIENT STABILITY 12

Review of numerical integration method; Simulation of power system dynamic response; Analysis of unbalanced faults; Case study of transient stability of a large system; Direct method of transient stability analysis.

UNIT V VOLTAGE STABILITY ANALYSIS : 12

Basic Concept of voltage stability; Voltage collapse; Voltage stability analysis modeling; Prevention of voltage collapse.

TOTAL PERIODS 60

COURSE OUTCOMES

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

- derive the voltage, current and flux linkage relationships in steady state analysis of synchronous machine.
- discuss the modeling of excitation to control and protective function for stability analysis.

- describe the significance about small signal stability analysis with controllers.
- analyze the stability of power system by point-by point method, modified Euler's and Runge – Kutta method.
- carry out a voltage stability analysis and preventing from voltage collapse.

REFERENCES

1. P.Kundur, "Power System Stability and Control", Tata McGraw-Hill, First Edition, Reprint 2018.
2. L.P.Singh, "Advanced Power System Analysis and Dynamics", New Age International Publishers, Sixth Edition, 2012.
3. K.R.Padiyar, "Power System Dynamics Stability and Control", BS Publications, Second Edition Reprint, 2018.
4. Dr.B.R.Gupta, "Power System Analysis and Design", S.Chand Publication, First Edition Reprint, 2015.

CO-PO MAPPING

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's (1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
CO's	Programme Outcomes PO's												PSO's	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	3	3	2	-	-	-	-	-	-	-	2	3	3
CO2	3	3	3	2	-	-	-	-	-	-	-	2	3	3
CO3	3	3	3	2	-	-	-	-	-	-	-	2	3	3
CO4	3	3	3	2	-	-	-	-	-	-	-	2	3	3
CO5	3	3	3	2	-	-	-	-	-	-	-	2	3	3

PPS23103 **POWER SYSTEM TRANSIENTS** **3 0 0 3**

COURSE OBJECTIVES

To enable the students to

- gain knowledge in sources of transients like lightning, switching and temporary overvoltages.
- model power system components and estimate the overvoltages in power system.
- analyze travelling wave phenomena against different overvoltages.
- compute transient overvoltages using electromagnetic transient program (EMTP).
- coordinate the insulation of power system and protective devices.

UNIT I LIGHTNING OVERVOLTAGES **9**

Classification of over voltages- Mechanism and parameters of lightning flash, protective shadow, striking distance, electro geometric model for lightning strike; 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**

Switching transients – concept, phenomenon, system performance under switching surges; Ferranti effect, temporary overvoltages, load rejection, line faults, ferro resonance, very fast transient overvoltage (VFTO).

UNIT III TRAVELLING WAVES ON TRANSMISSION LINE **9**

Circuits and distributed constants, wave equation, reflection and refraction ; Behaviour of travelling waves at the line terminations; Lattice diagrams – Attenuation and distortion; Multiconductor system and multivelocity waves

UNIT IV INSULATION CO-ORDINATION **9**

insulation co-ordination –Volt-time characteristics , insulation strength and their selection; Evaluation of insulation strength standard BIL's-Characteristics of protective devices, applications, location of arresters, insulation co-ordination in AIS and GIS.

UNIT V COMPUTATION OF POWER SYSTEM TRANSIENTS **9**

Computation of transients using electromagnetic transient program-Modelling of power system components; Simple case studies; Application of simplified method - Single line station, two line station, gas insulated substations, comparison with IEEE and IEC guides.

TOTAL PERIODS 45

COURSE OUTCOMES

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

- analyse various sources of transients.
- compute possible overvoltages in power systems.

- predict overvoltages in power system using travelling wave theory.
- compute overvoltages using EMTP with multiple sources.
- coordinate the insulation level of the power system.

REFERENCES

1. Pritindra Chowdhari, "Electromagnetic transients in Power System", John Wiley and Sons Inc., Second Edition, Reprint 2017.
2. Allan Greenwood, "Electrical Transients in Power System", Wiley & Sons Inc. New York, 2012.
3. Rakosh Das Begamudre, "Extra High Voltage AC Transmission Engineering", Second Edition Newage International (P) Ltd., New Delhi, Reprint, 2016.
4. Naidu M S and Kamaraju V, "High Voltage Engineering", Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2014.

CO-PO MAPPING

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	Programme Outcomes PO's												PSO's	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	2	3	-	2	-	-	-	-	-	-	-	2	3	3
CO2	2	3	-	2	-	-	-	-	-	-	-	2	3	3
CO3	2	3	-	2	-	-	-	-	-	-	-	2	3	3
CO4	2	3	-	2	-	-	-	-	-	-	-	2	3	3
CO5	2	3	-	2	-	-	-	-	-	-	-	2	3	3

PPS23104 **POWER SYSTEM INSTRUMENTATION** **3 0 0 3**

COURSE OBJECTIVES

To enable the students to

- understand the concept of temperature measurement and pressure measurement and its operations.
- present knowledge about various safety and miscellaneous sensors technologies that can be used in power system instrumentation.
- offer an opportunity to innovate newer procedures and better methods for effective design of instrumentation systems for power networks.
- provide knowledge about various possible of insulation measurements and system protection technologies that can be used.
- analyse the various metering, billing and collection.

UNIT I TEMPERATURE MEASUREMENT AND PRESSURE MEASUREMENT **9**

Radiation and infrared pyrometers; Resistance temperature detectors; Temperature switches and thermostats; Manometers; Multiple pressure scanners; Pressure repeaters; Pressure and differential pressure switches; Vacuum sensors.

UNIT II SAFETY AND MISCELLANEOUS SENSORS **9**

Explosion suppression and deluge systems - Flame arresters, conservation vents, and emergency vents; Flame, fire, and smoke detectors; Leak detectors -Linear and angular position detection; Machine vision technology; Metal detectors, noise sensors, proximity sensors and limit switches.

UNIT III DISTRIBUTION AUTOMATION **9**

Project planning – Definitions, communication; Sensors; Supervisory control and data acquisition (SCADA); Consumer information service (CIS); Geographical information system (GIS); Automatic meter reading (AMR); Automation systems; Distribution automation.

UNIT IV INSULATION MEASUREMENTS AND SYSTEM PROTECTION **9**

Insulation supervision - Insulation measurement; Non - destructive techniques -Insulation testing; Destructive tests -Transformer oil testing; Successful maintenance - Failures and maintenance; Porcelain insulators; Transformer oil maintenance; Transformer drying; Maintenance staff and tools; Maintenance costs.

UNIT V METERING, BILLING AND COLLECTION **9**

Solid-state meters - Advance meter infrastructure systems (AMI) , interval meter, net metering, meter current rating, prepaid electricity meters; Meter selection – Location, anti-theft meters; High voltage metering, reactive power metering, meter installation; Metering system errors – Testing methods; Digital meter, standards.

TOTAL PERIODS 45

COURSE OUTCOMES

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

- enumerate the concept of temperature measurement and pressure measurement.
- describe the components and architecture of safety and miscellaneous sensors.
- analyze the functioning of distribution automation in power system network.
- implement the controls involved in insulation measurements and system protection.
- analyse the metering, billing and collection.

REFERENCES

1. A.S.Pabla, "Electric Power Distribution", Tata McGraw Hill, New Delhi, Seventh Edition, 2019.
2. Bela G. Liptak, "Process Measurement and Analysis (Instrument Engineers Hand Book)", Butterworth-Heinemann Ltd, Fourth Edition, Reprint 2013.
3. Sherry A, "Modern Power Station Practice",Vol.6 (Instrumentation, Controls and Testing), Pergamon Press,1971.
4. Murphy.W.R and Mc Kay G "Energy Management" Butterworths Publications, London, 1982.

CO-PO MAPPING

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's (1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
CO's	Programme Outcomes PO's												PSO's	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	2	2	-	-	3	-	-	-	-	-	-	2	3	3
CO2	2	-	-	-	3	-	-	-	-	-	-	2	3	3
CO3	1	-	-	-	-	-	-	-	-	-	-	2	3	3
CO4	1	2	-	3	-	-	-	-	-	-	-	2	3	3
CO5	1	-	-	-	3	-	-	-	-	-	-	2	3	3

PEN23101 RESEARCH METHODOLOGY AND IPR 3 0 0 3

COURSE OBJECTIVES

To enable the students to

- understand the formulation of research problem
- be familiar with data collection and literature survey process
- know the statistical concepts in experimentation
- acquire knowledge in writing research proposal
- learn about patent rights and its importance

UNIT I RESEARCH PROBLEM FORMULATION 9

Meaning of research, Objectives of Research, Types of research, Significance of Research, Research process, Selecting the problem, Necessity of defining the problem, Meaning of Research design, Need for research design, features of a good design, Different research designs.

UNIT II LITERATURE SURVEY 9

Quantitative and Qualitative data, Scaling, Scaling Techniques, Experiments and Surveys, Collection of primary and secondary data, Data preparation process. Research problems, Effective literature studies approaches, Survey for existing literature, Procedure for reviewing the literature, Analysis and assessment.

UNIT III DESIGN OF EXPERIMENTS 9

Strategy of Experimentation - Typical applications of experimental design, Guidelines for designing experiments; Basic statistical concepts - Statistical concepts in experimentation, Regression approach to analysis of variance.

UNIT IV RESEARCH PROPOSAL AND WRITING 9

Contents of a research proposal, Writing a research report - Research writing in general, Referencing, Writing a bibliography, Presentation and assessment by a review committee, Plagiarism, Research ethics.

UNIT V INTELLECTUAL PROPERTY RIGHTS 9

Intellectual Property - Definition, WTO, Fundamentals of Patent, Copyright, Rights of the owner, Term of copyright, Register of trademark, Procedure for trade mark, Term of trademark; New Developments in IPR- Administration of patent system, IPR of Biological Systems, Computer Software.

TOTAL PERIODS 45

COURSE OUTCOMES

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

- identify research problems.
- collect and prepare suitable data for research.
- design experiments for different statistical concepts.
- write research proposals and reports.
- apply the research work for patent through IPR.

REFERENCES

1. C.R Kothari and Gaurav Garg, "Research Methodology Methods and Techniques", 4th Edition, New Age International Publishers, 2019.
2. Ranjit Kumar, "Research Methodology": A step by Step Guide for beginners, 2nd Edition, Pearson Education, 2010.
3. Douglas C. Montgomery, "Design and Analysis of Experiments", 9th edition, Wiley Publishers, 2017.
4. Neeraj Pandey and Khushdeep Dharni, "Intellectual Property Rights", Prentice Hall India Learning, 2014.

CO/PO Mapping:

Mapping of course outcome with Programme outcomes (1/2/3 indicates strength of correlation1-Low; 2-Medium ; 3-High)														
COs	**Programme Outcomes (POs)**													
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	3	1	-	-	1	-	2	-	-	3	2	2
CO2	3	3	-	1	2	-	1	-	2	3	-	3	2	2
CO3	3	3	3	2	2	-	-	-	3	2	1	3	2	2
CO4	3	3	-	-	1	1	-	3	2	3	-	3	2	2
CO5	3	-	-	2	2	3	1	3	3	-	2	2	2	2

PAC23101 **ENGLISH FOR RESEARCH PAPER WRITING** **2 0 0 0**

COURSE OBJECTIVES

To enable the students to

- improve the writing skills and level of readability.
- learn about what to write in each section and to understand the skills required to develop a title.
- choose a topic of interest and paraphrase, summarize, using correct attribution and following documentation guidelines.
- craft a research paper in their discipline.
- ensure the good quality of a research paper at first-time submission.

UNIT I PLANNING AND PREPARATION **6**

Precision of Words; Breaking up long sentences; Structuring paragraphs and sentences; Being concise and removing redundancy, avoiding ambiguity and vagueness; Expressing independent thought with grace, clarity and force.

UNIT II LITERATURE REVIEWS AND CITATIONS **6**

Key skills required - Write a title, an abstract, write an introduction, write the review of the literature, conduct a literature review of all current research in their field; Review of the Literature; Methods; Results; Discussion and Conclusions; Citing references correctly and avoiding plagiarism.

UNIT III WRITING STANDARDS **6**

Useful phrases - to ensure paper is as good as it could possibly be the first-time submission - first draft, second draft, final draft of research report; journal article; literature review; chapters, grant proposal; Avoid inadequate support of generalizations, slipshod or hurried style, poor attention to detail, straying from directions, mechanical errors, underwritten and/or marred by confused purpose, lack of organization, repetition of ideas, improper use of words, and frequent grammatical, spelling and punctuation errors.

UNIT IV STRUCTURE OF A PAPER **6**

Details of all the parts, Clarifying who did what; Highlighting the findings; Hedging and criticizing; Skills to identify something we really need to know, some ways to find a topic; To venture out across the swamp of research without losing our bearings; Paraphrasing; Sections of a paper - Abstract, introduction to free writing.

UNIT V EDITING AND ORGANISING SKILLS **6**

Skills required - write the methods, write the discussion, write the results, write conclusions; Write about what we've learned truthfully so the reader really gets it in thought and expression, demonstrating a clear understanding and execution of the research.

TOTAL PERIODS 30

COURSE OUTCOMES

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

- plan and write a research paper in their discipline.
- understand the basics of citations, avoiding plagiarism and literature reviews.
- write paraphrase, results and conclusions.
- culminate the actual crafting and revising of a research paper.
- use suitable vocabulary, grammar and punctuation to write flawless piece of writing.

REFERENCES

1. Goldbort R (2006) Writing for Science, Yale University Press.
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press.
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011.

CO-PO MAPPING

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's (1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
CO's	Programme Outcomes PO's												PSO's	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	-	-	-	2	-	1	-	-	3	-	1	-	-	-
CO2	-	3	-	2	2	2	-	1	3	3	2	-	-	-
CO3	-	1	-	-	-	-	2	3	3	-	-	-	-	-
CO4	-	-	-	3	-	-	-	2	3	-	-	-	-	-
CO5	-	2	2	3	-	-	-	-	3	-	-	2	-	-

PPS23105 **ADVANCED POWER SYSTEM SIMULATION LABORATORY I** **0 0 4 2**

COURSE OBJECTIVES

To enable the students to

- impart knowledge about load flow analysis through digital simulation.
- study the dynamic mechanisms behind angle and voltage stability problems in electric power systems, including physical phenomena and modelling issues.
- perform the estimation of different states of a power system.
- understand the performance of relay and generation dispatching scheme.

LIST OF EXPERIMENTS

1. Power flow analysis by Newton-Raphson method and fast decoupled method.
2. Transient stability analysis of single machine-infinite bus system using classical machine model.
3. Contingency analysis: Generator shift factors and line outage distribution factors.
4. Economic dispatch using Lambda-iteration method.
5. Unit commitment: Priority-list schemes and dynamic programming.
6. Analysis of switching surge using EMTP: Energisation of a long distributed parameter line.
7. Analysis of switching surge using EMTP: Computation of transient recovery voltage.
8. Simulation and implementation of voltage source inverter.
9. Digital over current relay setting and relay coordination.

TOTAL PERIODS 60

COURSE OUTCOMES

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

- investigate the power flow studies.
- reproduce the electromagnetic and electromechanical phenomena in the synchronous generator.
- enumerate the compensations schemes available in power systems.
- develop generation dispatching schemes in power systems.

CO-PO MAPPING

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	Programme Outcomes PO's												PSO's	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	2	2	3	3	-	-	-	-	-	-	-	3	3	3
CO2	2	2	3	3	-	-	-	-	-	-	-	3	3	3
CO3	2	2	3	3	-	-	-	-	-	-	-	3	3	3
CO4	2	2	3	3	-	-	-	-	-	-	-	3	3	3

SEMESTER II

PPS23201	RESTRUCTURED POWER SYSTEMS	3	1	0	4

COURSE OBJECTIVES

To enable the students to

- familiarize the concept of restructuring in power industry and models.
- impart knowledge on open access system and methodologies.
- provide knowledge about electricity marketing.
- clarify the concept of various electricity pricing.
- impart knowledge on reliability and deregulation.

UNIT I INTRODUCTION **12**

Restructuring model; Independent system operator; Power exchange; Market operation; Market power; Standard costs; Transmission pricing; Congestion pricing.

UNIT II OPEN ACCESS SAME TIME INFORMATION SYSTEM(OASIS) **12**

Structure of OASIS; Implementation of OASIS phases; Posting of information; Transfer capability on OASIS; Transmission services; Methodologies to calculate available transfer capability (ATC); Example with OASIS in some restructuring models.

UNIT III ELECTRICAL ENERGY MARKETING **12**

Essence of electric energy marketing; Energy marketing framework; Derivative instruments of energy marketing; Risk management - Effect of positions on risk management; Energy marketing hubs; Green power marketing.

UNIT IV ELECTRICITY PRICING **12**

Electricity price volatility; Electricity price indexes - Case study, volatility of price, basic risk; Challenges to electricity pricing; Construction of forward price curves; Short term price forecasting.

UNIT V RELIABILITY AND DEREGULATION **12**

Reliability analysis; Network model; Reliability cost; Hierarchical levels; Reliability and deregulation.

TOTAL PERIODS 60

COURSE OUTCOMES

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

- explain the importance of restructuring of power systems, different market models and the function of ISO role in power market.
- apply the concepts of open access system.
- analyze locational marginal pricing and explain the significance of financial transmission rights.
- explain the volatility, risk and forecasting of electricity pricing.
- outline the reform initiatives of deregulation.

REFERENCES

1. Mohammad Shahidehpour and Muwaffaq Almoush, "Restructured Electrical Power System: Operation, Trading and Volatility", CRC Press, First Edition, Reprint 2016.
2. Kankar Bhattacharya, Math H.J. Boolen, Jaap E. Daadler, "Operation of Restructured Power Systems", Springer, First Edition, Reprint, 2012.
3. S.R.Paranjothi, "Modern Power Systems", New Age International, First Edition, 2017.
4. Sally Hunt," Making Competition Work in Electricity", John Willey and Sons Inc. First Edition, Reprint 2017.

CO-PO MAPPING

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	Programme Outcomes PO's												PSO's	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	2	-	-	-	-	-	-	-	-	-	2	3	3
CO2	3	-	-	-	-	-	-	-	-	-	-	2	3	3
CO3	3	-	-	-	-	-	-	-	-	-	-	2	3	3
CO4	3	2	2	-	-	-	-	-	-	-	-	2	3	3
CO5	3	1	-	-	-	-	-	-	-	-	-	2	3	3

PPS23202 ADVANCED POWER SYSTEM PROTECTION 3 1 0 4

COURSE OBJECTIVES

To enable the students to

- know the numerical protection.
- understand the concept of digital protection in transmission line.
- understand the performance of synchronous generator and power transformer.
- comprehend about different relay settings.
- know the PC applications in short circuit studies.

UNIT V NUMERICAL PROTECTION 12

Introduction, block diagram of numerical relay, sampling theorem, correlation with a reference wave, least error squared (LES) technique, digital filtering, numerical overcurrent protection.

UNIT II DIGITAL PROTECTION OF TRANSMISSION LINE 12

Introduction, Protection scheme of transmission line, distance relays, traveling wave relays, digital protection scheme based upon fundamental signal, hardware design, software design, digital protection of EHV/UHV transmission line based upon traveling wave phenomenon, new relaying scheme using amplitude comparison.

UNIT III DIGITAL PROTECTION OF SYNCHRONOUS GENERATOR AND POWER TRANSFORMER 12

Introduction, faults in synchronous generator, protection schemes for synchronous generator, digital protection of synchronous generator. Faults in a transformer, schemes used for transformer protection, digital protection of transformer.

UNIT IV OVERCURRENT RELAY 12

Directional instantaneous IDMT overcurrent relay, directional multizone distance relay, distance relay setting, co-ordination of distance relays, co-ordination of overcurrent relays, computer graphics display, man-machine interface subsystem, integrated operation of national power system, application of computer graphics.

UNIT V PC APPLICATIONS IN SHORT CIRCUIT STUDIES FOR DESIGNING RELAYING SCHEME 12

Types of faults, assumptions, development of algorithm for S.C. studies, PC based integrated software for S.C. studies, transformation to component quantities, S.C. studies of multiphase systems; Ultra high speed protective relays for high voltage long transmission line.

TOTAL PERIODS 60

COURSE OUTCOMES

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

- explain about numerical protection.

- enumerate the concept of digital protection in transmission line.
- analyse the performance of synchronous generator and power transformer.
- describe about different relay settings.
- implement PC applications in short circuit studies.

REFERENCES

1. L. P. Singh, "Digital Protection - Protective Relaying from Electromechanical to Microprocessor", New Age International Ltd., New Delhi, Second Edition, Reprint, 2016.
2. S. R. Bhide, "Digital Power System Protection", Prentice Hall of India Pvt. Ltd., New Delhi, 2014.
3. Paithankar and Bhide, "Fundamentals of Power System Protection", Prentice Hall of India Pvt. Ltd., New Delhi, Second Edition, Reprint 2017.
4. T. S. M. Rao, "Digital / Numerical relays", Tata McGraw Hill, New Delhi, 2015.

CO-PO MAPPING

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	Programme Outcomes PO's												PSO's	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	2	-	-	-	-	-	-	-	-	-	2	3	3
CO2	3	-	3	3	-	-	-	-	-	-	-	2	3	3
CO3	3	-	-	-	-	-	-	-	-	-	-	2	3	3
CO4	3	2	-	-	-	-	-	-	-	-	-	2	3	3
CO5	3	-	-	-	-	-	-	-	-	-	-	2	3	3

PPS23203 **SMART GRID** **3 0 0 3**

COURSE OBJECTIVES

To enable the students to

- know the overview of smart grid and its functions.
- understand the data communication and its technologies.
- update the knowledge in smart metering and demand-side integration.
- relate the distribution automation and management systems.
- identify the case studies and test beds for the smart grid.

UNIT V INTRODUCTION TO SMART GRID 9

Today's grid versus the smart grid; Implementation of smart grid; Early smart grid initiatives; Overview of the technologies required for the smart grid; Functions of smart grid components and stakeholder roles.

UNIT II INFORMATION AND COMMUNICATION TECHNOLOGIES 9

Data communication - Switching techniques, communication channels, layered architecture and protocols; Communication technologies for the smart grid - Communication technologies, standards for information exchange; Information security for the smart grid - Encryption and decryption, authentication, digital signatures, cyber security standards.

UNIT III SENSING, MEASUREMENT, CONTROL AND AUTOMATION TECHNOLOGIES 9

Smart metering; Smart meters - An overview of the hardware, communications infrastructure and protocols for smart metering; Demand-side integration; Transmission system operation - Data sources, energy management systems, wide area applications, visualization techniques.

UNIT IV DISTRIBUTION AUTOMATION AND MANAGEMENT SYSTEMS 9

Distribution automation - Substation automation equipment, faults in the distribution system, voltage regulation; Distribution management - Data sources and associated external systems, modelling and analysis tools, applications.

UNIT V CASE STUDIES AND TEST BEDS FOR THE SMART GRID 9

Microgrid with renewable energy; Power system unit commitment (UC) problem; Adaptive dynamic programming (ADP) for optimal network reconfiguration in distribution automation; Case study of renewable energy resources (RER) integration- description of smart grid activity, approach for smart grid application; Test beds and benchmark systems ; Challenges and benefits of smart transmission.

TOTAL PERIODS 45

COURSE OUTCOMES

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

- categorize the overview of smart grid and its functions.
- illustrate the data communication and its technologies.
- describe the smart metering and demand-side integration.
- analyze the distribution automation and management systems.
- paraphrase the case studies and testbeds for the smart grid.

REFERENCES

1. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid:Technology and Applications", John Wiley & sons inc, 2012.
2. James Momoh, "Smart Grid: Fundamentals of design and analysis", John Wiley & sons Inc, IEEE press 2012.
3. Fereidoon P. Sioshansi, "Smart Grid: Integrating Renewable, Distributed & Efficient Energy", Academic Press, 2012.
4. Krzysztof Iniewski, "Smart Grid Infrastructure & Networking", Tata McGraw-Hill Edition, 2012.

CO-PO MAPPING

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	Programme Outcomes PO's												PSO's	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	3	3	-	-	-	-	-	-	-	-	3	3	3
CO2	3	3	3	-	-	-	-	-	-	-	-	3	3	3
CO3	3	3	3	-	-	-	-	-	-	-	-	3	3	3
CO4	3	3	3	-	-	-	-	-	-	-	-	3	3	3
CO5	3	3	3	-	-	-	-	-	-	-	-	3	3	3

PPS23204 POWER SYSTEM STATE ESTIMATION AND SECURITY ASSESSMENT 3 0 0 3

COURSE OBJECTIVES

To enable the students to

- introduce the state estimation on DC network.
- impart in-depth knowledge on power system state estimation.
- study alternative formulations of WLS state estimation.
- get insight of network observability and bad data identification.
- gain knowledge on power system security assessment.

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 and state 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.

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 PERIODS 45

COURSE OUTCOMES

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

- define various concepts implied in state estimation and its need in DC networks.
- apply State estimation algorithms in modelling of transmission lines.
- compare the different types of formulation techniques of state estimation.
- analyse network observability and identify the bad data detection using different methods.
- 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, Third Edition, Reprint, 2014.
2. J J Grainger and W D Stevension, " Power System Analysis", McGraw-Hill, Inc., Fourth Edition, 2016.
3. A Monticelli, "State Estimation in Electric Power Systems", Kluwer Academic Publishers, Seventh Edition,2016.
4. Mukhtar Ahmad, "Power System State Estimation", Lap Lambert Acad Publishers, 2013.

CO-PO MAPPING

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's (1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
CO's	Programme Outcomes PO's												PSO's	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	2	2	-	-	-	-	-	-	-	-	3	3	3
CO2	3	2	2	-	-	-	-	-	-	-	-	3	3	3
CO3	3	-	1	-	-	-	-	-	-	-	-	3	3	3
CO4	3	-	1	-	-	-	-	-	-	-	-	3	3	3
CO5	3	-	2	-	-	-	-	-	-	-	-	3	3	3

PAC23201 **PEDAGOGY STUDIES** **2 0 0 0**

COURSE OBJECTIVES

To enable the students to

- understand the aims, objectives and educational philosophies of education.
- acquire the knowledge of Instructional objectives of teaching and teaching skills.
- apply the knowledge of methods and strategies of teaching in real classroom situation.
- utilize the instructional aids and tools for effective classroom teaching.
- acquaint with the knowledge of professional development of teachers.

UNIT I EDUCATION AND ITS PHILOSOPHY 6

Education- Definition, Aims, Objectives, Scope, Educational philosophy of Swami Vivekananda, Mahatma Gandhi, Rabindranath Tagore, Sri Aurobindo and J.Krishnamoorthy, Montessori, Jean - Jacques Rousseau, Friedrich Froebel and John Dewey. Current trends and issues in Education - Educational reforms and National policy on Education - 1968 and 1986 - its objectives and features.

UNIT II INSTRUCTIONAL OBJECTIVES AND DESIGN 6

Instructional Objectives: Taxonomy of Educational objectives - Writing of general and specific objectives. Instructional design: Planning and designing the lesson, Writing of lesson plan: meaning, its need and importance, format of lesson plan. Types of lesson plan Skills of teaching: various ways of introducing lessons, explaining skills, problem solving skills, illustrative skills, scaffolding skills, integrating ICT skills, questioning skills, Reinforcement skills, skill of probing questions, skill of Stimulus variation and computation skills.

UNIT III INSTRUCTIONAL METHODS AND STRATEGIES 6

Instructional strategies Lecture, demonstration, laboratory, Inductive method, Deductive method, Inquiry method, seminar, panel discussion, symposium, problem solving, project based learning (PBL), Learning by doing, workshop, role - play (socio-drama), recent trends; Constructivist learning - Problem - based learning , brain - based learning , collaborative learning, flipped learning, blended learning, e-Learning trends, videoconferencing.

UNIT IV INSTRUCTIONAL MEDIA 6

Key concepts in the selection and use of media in education, developing learning resource material using different media; Instructional aids - Types, uses, selection, preparation, utilization; Dale cone of Experience; Teacher's role in procuring and managing instructional aids - Projected and non-projected aids, multimedia, video - teleconferencing etc.

UNIT V TEACHER PREPARATION 6

Teacher - Roles and responsibilities, functions, characteristics, competencies, qualities, preparation of professional teacher, organizing professional aspects of teacher preparation programs; Professional development of teachers - In-service training, refresher programmes, workshop and higher studies.

TOTAL PERIODS 30

PRACTICUM

- Writing of three lesson plans
- Practice teaching for 15 days
- Preparation of one teaching aid
- A seminar on one educational philosophy
- Assignment on any of these five units

COURSE OUTCOMES

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

- explain the educational philosophies of education.
- write instructional and specific objectives in lesson plan.
- utilize the teaching skills and methods effectively.
- use instructional media efficiently.
- update themselves in the area of professional development.

REFERENCES

1. National Policy on Education 1968 and 1986- National Policy on Education 1986-Programme of Action1992.
2. Benjamin S.Bloometal.(1987).Taxono my of educational objectives. Longman Group.
3. Siddiqui, Mujibul Hasan(2005). Techniques of classroom teaching A.P.H.
4. Jeffrey Bennett(2014).On Teaching Science: Principles and Strategies That Every Educator Should Know. Big Kid Science: Boulder, CO
5. Bawa,M.S.&Nagpal,B.M.(2010).Developing teaching competencies. New Delhi: Viva Book House.

CO-PO MAPPING

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's (1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
CO's	Programme Outcomes PO's												PSO's	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	-	-	-	-	-	2	-	3	-	-	-	-	-	-
CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	3	2	3	-	3	-	-
CO4	-	-	-	-	1	-	-	-	3	3	-	3	-	-
CO5	-	-	-	-	-	-	-	3	3	3	-	3	-	-

PPS23205 **ADVANCED POWER SYSTEM SIMULATION LABORATORY II** **0 0 4 2**

COURSE OBJECTIVES

To enable the students to

- understand the concept of SMIB using classical machine model.
- get idea to analyze two-bus system with STATCOM.
- know the details of relay protection.
- study about DFIG, PMSG in wind energy conversion system.

LIST OF EXPERIMENTS

1. Small-signal stability analysis of single machine-infinite bus system using classical machine model.
2. Small-signal stability analysis of multi-machine configuration with classical machine model.
3. Induction motor starting analysis.
4. Load flow analysis of two-bus system with STATCOM.
5. Transient analysis of two-bus system with STATCOM.
6. Available transfer capability calculation using an existing load flow program.
7. Study of variable speed wind energy conversion system- DFIG.
8. Study of variable speed wind energy conversion system- PMSG.
9. Computation of harmonic indices generated by a rectifier feeding a R-L load.
10. Co-ordination of over-current and distance relays for radial line protection.

TOTAL PERIODS 60

COURSE OUTCOMES

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

- implement the concept SMIB using classical machine model through simulation.
- analyze two-bus system with STATCOM.
- execute the relay protection circuit in simulation
- describe the concept of DFIG, PMSG in wind energy conversion system.

CO-PO MAPPING

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's (1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
CO's	Programme Outcomes PO's												PSO's	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	2	2	3	3	-	-	-	-	-	-	-	3	3	3
CO2	2	2	3	3	-	-	-	-	-	-	-	3	3	3
CO3	2	2	3	3	-	-	-	-	-	-	-	3	3	3
CO4	2	2	3	3	-	-	-	-	-	-	-	3	3	3

PROFESSIONAL ELECTIVES

PPS23151 ANALYSIS OF POWER CONVERTERS 3 0 0 3

COURSE OBJECTIVES

To enable the students to

- analyze and comprehend the various operating modes of different configurations of power converter
- know the operation of various inverter and their PWM controlling techniques.
- design different power converters DC to DC converters.
- learn the types of AC voltage controllers and basics of matrix converters.
- impart knowledge on different types of multilevel inverter and PWM techniques.

UNIT I CONVERTERS 9

Single phase half controlled and fully controlled converters – R Load, R-L loads and freewheeling diodes, continuous and discontinuous modes of operation, inverter operation; Effect of source impedance and overlap; Three phase Semi and fully controlled converter with R, R-L loads; Twelve pulse converter.

UNIT II INVERTERS 9

Principle of operation of half and full bridge inverters; Voltage control of single phase inverters using PWM techniques; Harmonic elimination techniques; 180 degree and 120 degree conduction mode inverters with star and delta connected loads.

UNIT III DC-DC CONVERTERS 9

Principles of step-down and step-up converters; Analysis of buck, boost, buck-boost and cuk converters; Time ratio and current limit control; Full bridge converter; Resonant and quasi-resonant converters.

UNIT IV AC VOLTAGE CONTROLLERS 9

Principle of phase control; Single phase and three phase controllers – Analysis with R and R-L loads; Principle of operation single phase and three phase cyclo-converters; Power factor control; Matrix converters.

UNIT V MULTILEVEL AND BOOST INVERTERS 9

Multilevel concept – Diode clamped, flying capacitor, cascade type multilevel inverters, comparison of multilevel inverters; Application of multilevel inverters; PWM techniques for multilevel inverters; Single phase and three phase impedance source inverters.

TOTAL PERIODS 45

COURSE OUTCOMES

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

- apply the different converter configuration based on the application.
- describe the single and three phase inverter.
- design a suitable DC-DC converter for given load specification.

- apply different types AC voltage controller based on the application.
- analyze the multilevel inverter for power system application.

REFERENCES

1. Rashid M.H., "Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Third Edition, New Delhi, 2014.
2. Bimal K.Bose, "Modern Power Electronics and AC Drives", Pearson Education, Second Edition, 2013.
3. Ned Mohan,T.M Undeland and W.P Robbin, "Power Electronics: converters, Application and design" John Wiley and sons, Wiley India Edition, 2016.
4. P.S.Bimbra, "Power Electronics", Khanna Publishers, Eleventh Edition, 2013.
5. Power Electronics by Vedam Subramanyam, New Age International publishers, New Delhi Second Edition, 2016.

CO-PO MAPPING

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	Programme Outcomes PO's												PSO's	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	2	1	1	2	1	-	-	-	-	-	2	3	3
CO2	3	2	1	2	2	1	-	-	-	-	-	2	3	3
CO3	3	1	1	1	2	1	-	-	-	-	-	2	3	3
CO4	3	1	1	1	1	1	-	-	-	-	-	2	3	3
CO5	3	1	1	1	1	1	-	-	-	-	-	2	3	3

PPS23152 **SYSTEM THEORY** **3 0 0 3**

COURSE OBJECTIVES

To enable the students to

- train on modeling and representing systems in state variable form.
- educate to solve linear and non-linear state equations.
- illustrate the properties of control system.
- identify non–linearities and examine stability of systems in the sense of Lyapunov's theory.
- educate on modal concepts, design of state, output feedback controllers and estimators.

UNIT I STATE VARIABLE REPRESENTATION **9**

Concept of state-space equations for dynamic systems -Time invariance and linearity, non-uniqueness of state model; Physical systems and state assignment - Free and forced responses; State diagrams.

UNIT II SOLUTION OF STATE EQUATIONS **9**

Existence and uniqueness of solutions to continuous-time state equations; Solution of nonlinear and linear time varying state equations; State transition matrix and its properties; Evaluation of matrix exponential-System modes, role of eigen values and eigen vectors.

UNIT III PROPERTIES OF THE CONTROL SYSTEM **9**

Controllability and observability, stabilizability and detectability, test for continuous time systems, time varying and time invariant case, output controllability; Reducibility-System realizations.

UNIT IV NON-LINEARITIES AND STABILITY ANALYSIS **9**

Equilibrium points-Stability in the sense of Lyapunov, BIBO stability, stability of LTI systems; Types of nonlinearity – Phase plane analysis ,singular points, limit cycles; Construction of phase trajectories – Describing function method, derivation of describing functions; Equilibrium stability of nonlinear continuous time autonomous systems - Direct method of Lyapunov and the linear continuous-time autonomous systems, Lyapunov Functions for nonlinear continuous time autonomous systems, Krasovskii and variable-gradiant method.

UNIT V MODAL ANALYSIS **9**

Controllable and observable companion forms - SISO and MIMO systems, effect of state feedback on controllability and observability, pole placement by state feedback for both SISO and MIMO systems; Full order and reduced order observers.

TOTAL PERIODS 45

COURSE OUTCOMES

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

- understand the concept of state-state representation for dynamic systems.
- explain the solution techniques of state equations.

- realize the properties of control systems in state space form.
- identify non-linearities and evaluate the stability of the system using lyapnov notion.
- perform modal analysis and design controller and observer in state space form.

REFERENCES

1. M. Gopal, "Modern Control System Theory", New Age International, Third Edition, Reprint 2015.
2. Z. Bubnicki, "Modern Control Theory", Springer, 2018.
3. K. Ogatta, "Modern Control Engineering", PHI, 2017.
4. D. Roy Choudhury, "Modern Control Systems", New Age International, 2015.

CO-PO MAPPING

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	Programme Outcomes PO's												PSO's	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	3	2	1	1	1	-	-	-	-	-	2	3	3
CO2	3	3	2	1	2	1	-	-	-	-	-	2	3	3
CO3	3	3	2	1	2	1	-	-	-	-	-	2	3	3
CO4	3	3	2	1	1	1	-	-	-	-	-	2	3	3
CO5	3	3	2	1	1	1	-	-	-	-	-	2	3	3

PAAVAI ENGINEERING COLLEGE, NAMAKKAL
Approved
BOARD OF STUDIES
Electrical & Electronics Engineering
AUTONOMOUS

PPS23153 **POWER SYSTEM RELIABILITY** **3 0 0 3**

COURSE OBJECTIVES

To enable the students to

- know the basic concepts of reliability engineering.
- understand about the probability methods in generating capacity.
- know the concept of frequency and duration methods in generating capacity.
- study the formation of system model.
- learn the importance of reliability indices in power system planning, expansion, operation and control.

UNIT I INTRODUCTION **9**

Definition of reliability and failure; Bathtub curve, concepts of probability; Evaluation techniques-Markov process, recursive technique; Security levels of system – Reliability cost, adequacy indices, functions of system security; Contingency analysis; Linear sensitivity factors, hierarchical levels in power system reliability assessment.

UNIT II GENERATING CAPACITY: BASIC PROBABILITY METHODS **9**

Generation system models – capacity outage probability tables, loss of load indices, equivalent forced outage rate, capacity expansion analysis, scheduled outages, evaluation methods on period basis, loss of energy indices.

UNIT III GENERATING CAPACITY: FREQUENCY AND DURATION METHOD **9**

Introduction – Generation model with no derated states, system risk indices with individual and cumulative load model; Practical system studies.

UNIT IV COMPOSITE GENERATION AND TRANSMISSION SYSTEM **9**

Introduction – Radial configurations, conditional probability approach, network configurations, state selection, system and load point indices; Application to practical system; Data requirements for composite system reliability evaluation.

UNIT V DISTRIBUTION SYSTEM **9**

Introduction – Evaluation techniques; Interruption indices: customer oriented, load and energy oriented; Application to radial systems – Effects of lateral distributor protection, disconnects, protection failures and transferring loads; Probability distribution of reliability indices.

TOTAL PERIODS 45

COURSE OUTCOMES

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

- acquire design knowledge of system components in reliability point of view.
- understand the importance of customer oriented and system oriented indices.

- illustrate the concept of frequency and duration methods in generating capacity.
- familiarize with reliability evaluation methodologies.
- analyse the system performance with proper remedial strategies.

REFERENCES

1. Dr. K. Uma Rao, "Power system operation & control", Wiley-India, First edition, 2013.
2. Ali Chowdhury, Don Koval, "Power Distribution System Reliability: Practical Methods and Applications", Wiley-IEEE Press, 2019.
3. Cepin, Marko, "Assessment of Power System Reliability", Springer, 2017.
4. Roy Billinton, R.N. Allan, "Reliability Evaluation of Power Systems", Springer, 2018.

CO-PO MAPPING

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	Programme Outcomes PO's												PSO's	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	2	2	-	-	2	1	-	-	-	-	-	2	3	3
CO2	2	1	1	-	2	1	-	-	-	-	-	2	3	3
CO3	2	1	1	-	2	1	-	-	-	-	-	2	3	3
CO4	2	2	-	-	1	1	-	-	-	-	-	2	3	3
CO5	2	1	-	-	1	1	-	-	-	-	-	2	3	3

PPS23154 **DESIGN OF SUBSTATION** **3 0 0 3**

COURSE OBJECTIVES

To enable the students to

- gather knowledge about air insulated (AI) and gas insulated (GI) substations.
- aware of substation equipment and their arrangements.
- understand the concepts of insulation coordination and standards of substation.
- comprehend substation grounding system and shielding.
- know about the source and effect of fast transients in air insulated, gas insulated substations.

UNIT I INTRODUCTION **9**

Introduction – characteristics, comparison of air insulated substation (AIS) and gas insulated substation (GIS), main features of substations; Environmental considerations, planning and installation; Gas insulated line (GIL),gas insulated busducts (GIB).

UNIT II MAJOR EQUIPMENT AND LAYOUT **9**

Major equipment of AIS and GIS - 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 half scheme, ring bus.

UNIT III INSULATION COORDINATION **9**

Introduction to insulation coordination of AIS and GIS – Stress at the equipment, insulation strength and its selection, standard basic impulse level (BIL); Application of simplified method; Comparison with IEEE and IEC guides.

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 wires and masts.

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

Introduction – Disconnector switching in relation to very fast transients overvoltage, origin of VFTO, propagation and mechanism of VFTO, VFTO characteristics, effects of VFTO.

TOTAL PERIODS 45

COURSE OUTCOMES

At the end this course, students will be able to

- express the fundamentals of air insulated (AI) and gas insulated (GI) substations.
- describe the assembly of substation equipment's.

- deliver standards of insulation coordination.
- design the substation grounding system and shielding.
- implement the effects of fast transients in AIS and GIS.

REFERENCES

1. Andrew R. Hileman, "Insulation Coordination for Power Systems", Taylor and Francis, 2015.
2. M.S. Naidu, "Gas Insulation Substations", I.K. International Publishing House Private Limited, 2018.
3. Klaus Ragallar, "Surges in High Voltage Networks" Plenum Press,New York, 2016.
4. Pritindra Chowdhuri, "Electromagnetic Transients in Power Systems", PHI Learning Private Limited, New Delhi, Second edition, 2014.

CO-PO MAPPING

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	Programme Outcomes PO's												PSO's	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	2	1	-	-	1	1	-	-	-	-	-	2	3	3
CO2	2	1	-	-	2	1	-	-	-	-	-	2	3	3
CO3	2	1	-	-	2	1	-	-	-	-	-	2	3	3
CO4	2	1	-	-	1	1	-	-	-	-	-	2	3	3
CO5	2	1	-	-	1	1	-	-	-	-	-	2	3	3

PPS23155 ANALYSIS OF ELECTRICAL MACHINES 3 0 0 3

COURSE OBJECTIVES

To enable the students to

- provide knowledge about the fundamentals of magnetic circuits.
- recognize the steady state and dynamic state operation of DC machine.
- impart knowledge on theory of transformation of three phase variables to two phase variables.
- analyze the steady state operation of three-phase induction machines using transformation theory based mathematical modeling.
- familiarize on steady state and dynamic state operation of three-phase synchronous machines using transformation theory based mathematical modeling.

UNIT I ELECTROMAGNETIC ENERGY CONVERSION 9

Magnetically coupled circuits - Linear magnetic system, nonlinear magnetic system; Electromechanical energy conversion - Energy relationships, energy in coupling fields; Machine winding and air gap magneto motive force; Winding inductance and voltage equations.

UNIT II DIRECT- CURRENT MACHINES 9

Elementary direct current (DC) machine - Voltage and torque equations, Basic types of direct current machines, separate winding excitation, shunt connected DC machine, series connected dc machine and compound connected dc machine; Dynamic characteristics of permanent magnet and shunt DC motor; Time domain block diagrams and state equations.

UNIT III REFERENCE FRAME THEORY 9

Equations of transformation - Changes of variables; Stationary circuit variables transformed to the arbitrary reference frame; Commonly used reference frames; Transformation between reference frames; Transformation of a balanced set; Balanced steady state phasor relationships; Balanced steady state voltage equations.

UNIT IV SYMMETRICAL INDUCTION MACHINES 9

Voltage equations in machine variables; Torque equation in machine variables; Equations of transformation for rotor circuits; Voltage equations in arbitrary reference frame variables; Torque equation in arbitrary reference frame variables; Analysis of steady-state operation; Free acceleration characteristics - Free acceleration characteristics viewed from various reference frames; Dynamic performance during sudden changes in load torque.

UNIT V SYNCHRONOUS MACHINES 9

Voltage equations in machine variables; Torque equation in machine variables; Stator voltage equations in arbitrary reference frame variables; Voltage equations in rotor reference frame variables - Park's equations; Rotor angle and angle between rotors; Analysis of steady state operation; Dynamic performance during a sudden change in input torque; Dynamic performance during three phase fault at the machine terminals.

TOTAL PERIODS 45

COURSE OUTCOMES

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

- understand the fundamentals of magnetic circuits.
- learn the steady state and dynamic state operation of dc machine.
- known the theory of transformation of three phase variables to two phase variables.
- understand the steady state operation of three-phase induction machines using transformation theory based mathematical modeling.
- learn the steady state and dynamic state operation of three-phase synchronous machines using transformation theory based mathematical modeling.

REFERENCES

1. Paul C.Krause, Oleg Wasyzczuk, Scott S, Sudhoff, "Analysis of Electric Machinery and Drive Systems", John Wiley, Second Edition, reprint 2018.
2. P S Bimbhra, "Generalized Theory of Electrical Machines", Khanna Publishers, 2021.
3. A.E, Fitzgerald, Charles Kingsley, Jr, and Stephan D, Umanx, " Electric Machinery", Tata McGraw Hill, 6th Edition, reprint 2015.
4. Hamid A. Toliyat, Subhasis Nandi,Seungdeog Choi,Homayoun Meshgin-Kelk, "Electric Machines: Modeling, Condition Monitoring, and Fault Diagnosis", CRC Press, 2013.

CO-PO MAPPING

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	Programme Outcomes PO's												PSO's	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	2	1	1	1	-	2	-	-	-	-	-	1	3	3
CO2	3	2	2	1	-	1	-	-	-	-	-	2	3	3
CO3	2	2	2	1	-	1	-	-	-	-	-	1	3	3
CO4	3	2	1	1	-	1	-	-	-	-	-	2	3	3
CO5	3	2	1	1	-	1	-	-	-	-	-	1	3	3

Approved
BOARD OF STUDIES
Electrical & Electronics Engineering

PPS23156 **IOT FOR SMART SYSTEMS** **3 0 0 3**

COURSE OBJECTIVES

To enable the students to

- study about internet of things(IoT) technologies and its basics.
- introduce the network architecture and design required for IoT.
- familiarize the principles behind the internet connectivity principles for IoT.
- provide insight about the data acquiring, processing, organizing and analytics.
- discuss the applications and case study of IoT.

UNIT I INTRODUCTION TO INTERNET OF THINGS 9

Internet of Things - Definition, vision, smart and hyper connected devices; IoT conceptual framework; IoT architectural view; Technology behind IoT - Server end technology, major components of IT system, API's and device interfacing components, platforms and integration tools; Sources of IoT - Popular IoT development boards, role of RFID and IoT Applications, wireless sensor networks (WSNs); M2M Communication - M2M to IoT, M2M architecture, software and development tools.

UNIT II IOT NETWORK ARCHITECTURE AND DESIGN 9

Drivers behind new network architectures - Scale, security, constrained devices and networks, data, legacy device support; Comparing IoT architectures - One M2M IoT standardized architecture, IoT world forum (IoT WF) standardized architecture; IoT data management and compute stack - Fog computing, edge computing, hierarchy of edge, fog and cloud.

UNIT III INTERNET CONNECTIVITY PRINCIPLES 9

Internet connectivity; Internet based communication - Internet protocols, 6LoWPAN; IP addressing in the IoT - IP address, IPv6 address; Media access control; Application layer protocols - HTTP and HTTPS ports.

UNIT IV DATA ACQUIRING, ORGANISING, PROCESSING AND ANALYTICS 9

Data acquiring and storage - Data generation, data acquisition, data validation, data store, data centre management, server management, spatial storage; Organizing the data - Query processing, SQL, NOSQL, extract, transform and load; Analytics - Event analytics, In-memory data processing and analytics, real-time analytics management; Knowledge acquiring, managing and storing process.

UNIT V IOT APPLICATIONS AND CASE STUDY 9

IoT applications - Smart home, smart city, smart environment-monitoring, smart agriculture; Case study – Smart city streetlights control and monitoring.

TOTAL PERIODS 45

COURSE OUTCOMES

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

- analyze the basic concepts of IoT and its present developments.
- compare and contrast about different architecture of IoT.
- explain different internet connectivity principles.
- analyze the data analytic and data acquiring, organising, processing of IoT.
- implement IoT solutions for smart applications.

REFERENCES

1. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, "IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things", Cisco Press, First Edition, 2017.
2. Rajkamal, "Internet of Things: Architecture, Design Principles and Applications", McGraw Hill Higher Education, Standard Edition, 2022.
3. Olivier Hersent, David Boswarthick, Omar Elloumi, "The Internet of Things: Key applications and Protocols" Wiley, First Edition, 2012.
4. JanHoller, VlasiosTsiatsis, Catherine Mulligan, Stamatis, Karnouskos, Stefan Avesand, David Boyle "From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence", Elsevier, First Edition, 2014.

CO-PO MAPPING

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	Programme Outcomes PO's												PSO's	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	2	1	-	-	-	1	-	-	-	-	-	2	3	3
CO2	2	1	2	-	-	2	-	-	-	-	-	1	3	3
CO3	2	1	-	-	-	2	-	-	-	-	-	2	3	3
CO4	2	1	1	-	-	1	-	-	-	-	-	2	3	3
CO5	2	1	1	-	-	1	-	-	-	-	-	1	3	3

KAAVAI ENGINEERING COLLEGE, NAMAKKAL
Approved
BOARD OF STUDIES
Electrical & Electronics Engineering
AUTONOMOUS

PPS23157 POWER ELECTRONICS APPLICATION TO WIND AND SOLAR ENERGY SYSTEMS **3 0 0 3**

COURSE OBJECTIVES

To enable the students to

- impart knowledge on wind energy conversion.
- familiarize on different types of power converters used in wind energy conversion systems.
- understand the process of solar energy conversion using photovoltaic (PV) system.
- impart detailed knowledge on grid connected PV system and MPPT (maximum power point tracking) algorithms.
- recognize the different configuration of hybrid energy system and their control.

UNIT I WIND ENERGY CONVERSION SYSTEMS **9**

Power in the Wind; Wind turbine design considerations; Grid connected wind farms; Hybrid power systems; Classification of wind turbine rotors; Common generator types in wind turbines; Different configurations for connecting wind turbines to the grid - Economic analysis of wind systems.

UNIT II POWER ELECTRONICS FOR WIND TURBINES **9**

Development of wind power generation; Wind power conversion; Power converters for wind turbine - Two level power converter, multilevel power converter, multi cell converter; Power semiconductors for wind power converter; Controls and grid requirements for modern wind turbines - Active power control - Reactive power control - Total harmonic distortion - Fault ride through capability; Emerging reliability issues for wind power system.

UNIT III SOLAR ENERGY CONVERSION SYSTEMS **9**

PV modules - Shading effects on PV modules - Performance of solar cells and modules; Types of PV systems - Grid connected system, off grid system; Solar thermal systems; Concentrating solar power systems; Low temperature solar thermal approaches; Environmental impact.

UNIT IV POWER ELECTRONICS FOR PHOTOVOLTAIC SYSTEMS **9**

Power curves and maximum power point of PV systems - Electrical model of a PV cell, Photovoltaic module I-V and P-V curves, MPP under partial shading; Grid connected PV system configurations - centralized configuration, string configuration, multi string configuration, AC (alternating current) module configuration; Control of grid-connected PV systems - Maximum power point tracking control methods, DC-DC (Direct Current) stage converter control, grid tied converter control, anti-islanding detection; Recent developments in multilevel inverter based PV systems.

UNIT V POWER ELECTRONICS FOR HYBRID ENERGY SYSTEMS(HES) 9

Renewable energy based hybrid power system; PV diesel battery system overview; AC bus connected HES; DC-bus connected HES; DC-side integration of HES; Three port converters; DC-DC converter; High-frequency link; Neutral-point-clamped multilevel converters with multiple energy sources; Cascaded and modular multilevel converters; Solid state transformers.

TOTAL PERIODS 45

COURSE OUTCOMES

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

- explain the basics of wind energy conversion system.
- elucidate power conversion in wind energy conversion system.
- describe the process of solar energy conversion system.
- use the converters for solar energy conversion.
- implement the concept of hybrid renewable energy conversion using power converters.

REFERENCES

1. Ahmed F Zobaa and Ramesh Bansal, "Handbook of Renewable Energy Technology", World Scientific Publishing Co. Pvt. Ltd., First Edition, 2017.
2. Haitham Abu-Rub, Mariuz Malinowski, Kamal AL-Haddad, "Power Electronics for Renewable Energy Systems, Transportation and Industrial Applications", IEEE Press and John Wiley & Sons Ltd, First edition, 2014.
3. Ersan Kabalci, "Hybrid Renewable Energy Systems and Microgrids", Academic Press, First Edition, 2021.
4. Mukund R.Patel, "Wind and Solar Power Systems Design, Analysis and Operation", CRC Press, Third Edition, 2021.

CO-PO MAPPING

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	Programme Outcomes PO's												PSO's	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	1	2	-	1	1	-	-	-	-	-	2	3	3
CO2	3	2	2	1	1	2	-	-	-	-	-	2	3	3
CO3	3	1	2	-	1	1	-	-	-	-	-	2	3	3
CO4	3	2	1	1	1	1	-	-	-	-	-	2	3	3
CO5	3	-	2	-	1	1	-	-	-	-	-	2	3	3

PPS23158 SOLAR AND ENERGY STORAGE SYSTEMS 3 0 0 3

COURSE OBJECTIVES

To enable the students to

- know about the photovoltaic systems.
- understand the basic knowledge on power conditioning for photovoltaic power system.
- recognize the measurement and characterization of solar cells and modules.
- Identify the electrochemical storage for photovoltaics.
- get knowledge on energy collected and delivered by PV modules.

UNIT I PHOTOVOLTAIC SYSTEMS 9

Introduction to photovoltaic (PV) Systems; Principles of photovoltaic power system configuration and their application; Components for PV Systems; Future developments in photovoltaic system technology.

UNIT II POWER CONDITIONING FOR PHOTOVOLTAIC POWER SYSTEM 9

Charge controllers and monitoring systems for batteries in PV power systems - Charge controllers, Charge equaliser for long battery strings; Inverters- General characteristics of PV inverters, grid-connected systems, stand-alone operation, power quality, active quality control and safety aspects.

UNIT III MEASUREMENT AND CHARACTERIZATION OF SOLAR CELLS AND MODULES 9

Rating PV performance; Current versus voltage measurements; Spectral responsivity measurements - Filter-based systems, grating-based systems; Module qualification and certification.

UNIT IV ELECTROCHEMICAL STORAGE FOR PHOTOVOLTAICS 9

General concept of electrochemical batteries; Typical operation conditions of batteries in PV applications; Secondary electrochemical accumulators with internal storage; Secondary electrochemical battery systems with external storage; Investment and lifetime cost considerations.

UNIT V ENERGY COLLECTED AND DELIVERED BY PV MODULES 9

Introduction; Movement between sun and earth; Solar radiation components; Radiation on inclined surfaces; Diurnal variations of the ambient temperature; Effects of the angle of incidence and of the dirt; Irradiation on most widely studied surfaces; PV generator behaviour under real operation conditions; Reliability and sizing of stand-alone PV systems.

TOTAL PERIODS 45

COURSE OUTCOMES

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

- illustrate the the photovoltaic systems.
- explain the basic knowledge on power conditioning for photovoltaic power system.
- describe about the measurement and characterization of solar cells and modules.

- use the electrochemical storage for photovoltaics.
- apply the knowledge on energy collected and delivered by PV modules.

REFERENCES

1. Hegedus, S. and Luque, A. eds.,, "Handbook of Photovoltaic Science and Engineering", John Wiley & Sons 2015.
2. Solanki C.S., "Solar Photovoltaics: Fundamentals, Technologies And Applications", PHI Learning Pvt. Ltd.,2015.
3. Stuart R.Wenham, Martin A.Green, Muriel E. Watt and Richard Corkish, "Applied Photovoltaics", ,Earthscan, UK, 2017.
4. Frank S. Barnes & Jonah G. Levine, "Large Energy Storage Systems Handbook", CRC Press, 2015.

CO-PO MAPPING

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's (1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
CO's	**Programme Outcomes PO's**												**PSO's**	
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**
CO1	2	2	1	-	1	1	-	-	-	-	-	2	3	3
CO2	2	1	1	-	1	1	-	-	-	-	-	2	3	3
CO3	3	2	-	-	1	1	-	-	-	-	-	2	3	3
CO4	2	1	-	-	1	1	-	-	-	-	-	2	3	3
CO5	3	2	-	-	1	1	-	-	-	-	-	2	3	3

PPS23159 PYTHON FOR POWER SYSTEMS ENGINEERING 3 0 0 3

COURSE OBJECTIVES

To enable the students to

- use the basic programming principles such as data types, variable, conditionals, loops, recursion and function calls
- use basic data structures and manipulate text files and images.
- familiar with machine learning concepts and techniques.
- understand the process and will acquire skills necessary to effectively attempt a machine learning problem and implement it using python.
- familiarizing the concepts acquired to improve research/employability skills.

UNIT I INTRODUCTION TO MACHINE LEARNING AND PYTHON 9

Introduction to machine learning- Significance, advantage and applications; Categories of machine learning; Basic steps in machine learning - Raw data collection, pre-processing, training a model, evaluation of model, performance improvement; Introduction to python and its significance; Difference between C, C++ and Python Languages; Compiler and interpreters; Python3 installation and running; Basics of Python programming syntax - Variable types, basic operators, reading input from user; Arrays/list, dictionary and set, conditional statements, control flow and loop control statements.

UNIT II PYTHON FUNCTIONS AND PACKAGES 9

File Handling- Reading and writing data; Errors and exceptions handling; Functions and modules; Package handling in python; Pip installation and exploring functions in python package; Installing the numpy library and exploring various operations on arrays - Indexing, slicing, multi-dimensional arrays, joining numpy arrays, array intersection and difference, saving and loading numpy arrays; Introduction to SciPy package and its functions; Introduction to object oriented programming with python.

UNIT III IMPLEMENTATION OF MACHINE LEARNING USING PYTHON 9

Description of standard datasets - Coco, imagenet, MNIST (handwritten digits) dataset, Boston housing dataset; Introducing the concepts of regression; Linear, polynomial and logistic regression with analytical understanding; Introduction to SciPy package and its functions; Python application of linear regression and polynomial regression using SciPy; Interpolation, overfitting and underfitting concepts and examples using SciPy.

UNIT IV CLASSIFICATION AND CLUSTERING CONCEPTS OF ML 9

Introduction to ML concepts of clustering and classification; Types of classification algorithms; Support vector machines (SVM) ; Decision tree; Random forest; Introduction to ML using scikitlearn; Using scikit-learn, loading a sample dataset, learning and prediction, interpolation and fitting, multiclass fitting; Implementation of SVM using blood cancer dataset, decision tree using data from csv. Types of clustering algorithms and techniques; K-means algorithm, mean shift algorithm and hierarchical clustering algorithm; Introduction to python visualization using Matplotlib - Plotting 2- dimensional, 3-dimensional graphs, formatting axis values, plotting multiple rows of data in same graph.

UNIT V INTRODUCTION TO NEURAL NETWORKS AND EMBEDDED MACHINE LEARNING **9**

Introduction to neural networks and significance – Neural network architecture, single layer perceptron and multi-layer perceptron (MLP), commonly used activation functions; Forward propagation, back propagation, and epochs, gradient descent; Introduction to convolution neural networks; Implementation of digit classification using MNIST dataset ML for embedded systems

TOTAL PERIODS 45

COURSE OUTCOMES

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

- implement skill in system administration and network programming by learning python.
- demonstrate the concepts of machine learning and implement using python.
- relate Pythons highly powerful processing capabilities for primitives, modelling etc.,
- improve the employability and entrepreneurship capacity due to knowledge upgradation on recent trends in embedded systems design.
- apply the concepts acquired over the advanced research/employability skills.

REFERENCES

1. Mark Lutz, "Learning Python, Powerful OOPs",O'reilly,2017.
2. Zelle, John "M. "Python Programming: An Introduction to Computer Science.", Franklin Beedle & Associates, 2013.
3. Andreas C. Müller, Sarah Guido, "Introduction to Machine Learning with Python", O'Reilly, 2016.
4. Sebastian Raschka , Vahid Mirjalili, "Python Machine Learning - Third Edition", Packt, December 2019.

CO-PO MAPPING

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	Programme Outcomes PO's												PSO's	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	2	2	1	2	1	-	-	-	-	-	2	3	3
CO2	3	2	2	1	2	1	-	-	-	-	-	2	3	3
CO3	3	2	2	1	2	1	-	-	-	-	-	2	3	3
CO4	3	2	2	1	2	1	-	-	-	-	-	2	3	3
CO5	3	2	2	1	2	1	-	-	-	-	-	2	3	3

PAAVAI ENGINEERING COLLEGE
Approved
BOARD OF STUDIES
Electrical & Electronics Engineering
AUTONOMOUS

PPS23160 ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY IN SYSTEM DESIGN **3 0 0 3**

COURSE OBJECTIVES

To enable the students to

- recognize the basic of electromagnetic compatibility and its application.
- impart knowledge on cabling and grounding fundamentals.
- know about the importance of balancing and filters.
- acquire knowledge on electromagnetic interface (EMI) from apparatus and circuits.
- understand the process of electrostatic discharge (ESD).

UNIT I ELECTROMAGNETIC COMPATIBILITY AND APPLICATIONS **9**

Noise and interface; Designing for electromagnetic compatibility; Regulatory process; Methods of noise coupling; Miscellaneous noise sources; Use of network theory; Power supply decoupling; Transient power supply currents; Decoupling capacitors; Effective decoupling strategies.

UNIT II CABLING AND GROUNDING **9**

Capacitive coupling; Effect on shield on capacitive coupling; Inductive coupling; Mutual inductance calculations; Effect of shield on magnetic coupling; Shielding to prevent magnetic radiation; Shielding a receptor against magnetic fields; common impedance shield coupling; AC power distribution and safety grounds; Signal grounds; Equipment grounding; Ground loops.

UNIT III BALANCING AND FILTERING **9**

Balancing – Common mode rejection ratio, cable balance, system balance, balanced loads; Filtering – Common mode filters, parasitic effects in filters; Power supply decoupling – Low frequency analog circuit decoupling, amplifier decoupling; Driving capacitive loads; System bandwidth; Modulation anding.

UNIT IV EMI FROM APPARATUS AND CIRCUITS **9**

Electromagnetic emissions – Systems, appliances; Noise from relays and switches – Circuit model, Noise characteristics, effects of interfaces; Nonlinearities in circuits – Amplifier nonlinearity, modulation, intermodulation, cross modulation; Passive intermodulation; Cross talk in transmission lines – Multiconductor line, three conductor line; Transients in power supply lines – Calculation of induced voltages and currents, surges on main power supply; Electromagnetic interface – Radiation coupling, Conduction coupling, combination of radiation and conduction.

UNIT V ELECTROSTATIC DISCHARGE **9**

Static generation – Inductive charging, energy storage; Human body model; Static discharge – Decay time; ESD protection in equipment's design; Preventing ESD entry; Hardening sensitive circuits; ESD grounding; Non grounded products; Field induced upset; Transient hardened software design; Time windows.

TOTAL PERIODS 45

COURSE OUTCOMES

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

- explain the basics of electromagnetic compatibility and its application.
- describe the process of on cabling and grounding fundamentals.
- elucidate the importance of balancing and filters.
- examine the effect of electromagnetic interface (EMI) from apparatus and circuits.
- implement the concept electrostatic discharge in various applications.

REFERENCES

1. Henry W.Ott, "Electromagnetic Compatibility Engineering", First Edition, John Wiley & Sons, Inc., Second Edition, Reprint 2019.
2. V.Prasad Kodali, "Engineering Electromagnetic Compatibility", IEEE Press and John Wiley & Sons Ltd, First edition, Reprint 2017.
3. David A. Weston, "Electromagnetic Compatibility: Methods, Analysis, Circuits and Measurement", CRC Press, Third Edition, 2016.
4. Clayton Paul, "Introduction to Electromagnetic Compatibility", John Wiley & Sons, Inc., Third Edition, 2022.

CO-PO MAPPING

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's (1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
CO's	Programme Outcomes PO's												PSO's	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	3	1	-	-	1	-	-	-	-	-	2	3	3
CO2	3	2	2	-	-	1	-	-	-	-	-	2	3	3
CO3	3	1	1	1	-	1	-	-	-	-	-	2	3	3
CO4	3	1	1	-	-	1	-	-	-	-	-	2	3	3
CO5	3	2	2	-	-	1	-	-	-	-	-	2	3	3

PPS23161 POWER QUALITY 3 0 0 3

COURSE OBJECTIVES

To enable the students to

- provide knowledge about various power quality issues.
- understand the concept of power and power factor in single phase and three phase systems supplying nonlinear loads.
- equip with required skills to design conventional compensation techniques for power factor correction and load voltage regulation.
- introduce the control techniques for the active compensation.
- understand the mitigation techniques using custom power devices such as DSTATCOM, DVR and UPQC.

UNIT I INTRODUCTION **9**

Characterization of electric power quality - Transients, short duration and long duration voltage variations, voltage imbalance, waveform distortion, voltage fluctuations, power frequency variation, power acceptability curves; Power quality problems - Poor load power factor, non-linear and unbalanced loads, DC offset in loads, notching in load voltage; Disturbance in supply voltage – Power quality standards.

UNIT II ANALYSIS OF SINGLE PHASE AND THREE PHASE SYSTEM **9**

Single phase linear and non-linear loads – single phase sinusoidal, non-sinusoidal source; Supplying linear and nonlinear loads – Three phase balanced system, three phase unbalanced system, three phase unbalanced and distorted source supplying non-linear loads; Concept of power factor; Three phase- three wire, three phase - four wire system.

UNIT III CONVENTIONAL LOAD COMPENSATION METHODS **9**

Principle of load compensation and voltage regulation; Classical load balancing problem - Open loop balancing, closed loop balancing, current balancing, harmonic reduction and voltage sag reduction; Analysis of unbalance – Instantaneous of real and reactive powers; Extraction of fundamental sequence component from measured.

UNIT IV LOAD COMPENSATION USING DSTATCOM **9**

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

UNIT V SERIES COMPENSATION OF POWER DISTRIBUTION SYSTEM 9

Rectifier supported DVR; DC capacitor supported DVR; DVR structure; Voltage restoration; Series active filter; Unified power quality conditioner.

TOTAL PERIODS 45

COURSE OUTCOMES

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

- comprehend the consequences of power quality issues.
- conduct harmonic analysis of single phase and three phase systems supplying non-linear loads
- design passive filter for load compensation.
- design active filters for load compensation.
- understand the mitigation techniques using custom power devices such as distribution static compensator DSTATCOM, dynamic voltage restorer DVR and UPQC.

REFERENCES

1. .Arindam Ghosh and Gerad Ledwich "Power Quality Enhancement Using Custom Power Devices",Kluwer Academic Publishers, First Edition, Reprint 2019.
2. G.T.Heydt, "Electric Power Quality", Stars in a Circle Publications, Second Edition, Reprint 2016.
3. R.C.Duggan "Electric Power Systems Quality", Tata MC Graw Hill Publishers, Third Edition Reprint, 2019.
4. Derek A.Paice "Power Electronic Converter Harmonics" IEEE Press, 2014.

CO-PO MAPPING

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	Programme Outcomes PO's												PSO's	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	2	1	-	-	1	-	-	-	-	-	2	3	3
CO2	3	2	1	-	-	1	-	-	-	-	-	2	3	3
CO3	3	2	1	-	-	1	-	-	-	-	-	2	3	3
CO4	3	1	1	-	-	1	-	-	-	-	-	2	3	3
CO5	3	1	1	-	-	1	-	-	-	-	-	2	3	3

PPS23162 APPLICATION OF DSP TO POWER SYSTEM PROTECTION 3 0 0 3

COURSE OBJECTIVES

To enable the students to

- expose the students to learn about DFT and wavelet transforms.
- provide an in-depth knowledge on the components used for the implementation of digital protection.
- impart knowledge on different algorithms for digital protection of power system components.
- implement digital protection for transformer.
- understand different decision making methodologies in protective relays.

UNIT I DIGITAL SIGNAL PROCESSING TECHNIQUES 9

Sampling-Principle of scaling-aliasing, decimation, interpolation; Fourier and discrete fourier transforms; Fast fourier transforms; Wavelet transform; Numerical algorithms.

UNIT II DIGITAL PROTECTION 9

Digital protection - Performance and operational characteristics of digital protection; Basic components of digital relays -Signal conditioning systems, conversion subsystem, digital relay subsystem; Numerical relay for generator, transformer, feeder, busbar protection.

UNIT III ALGORITHMIC TECHNIQUES 9

Finite difference techniques- Interpolation, numerical differentiation, curve fitting and smoothing; Sinusoidal wave based algorithms -First and second derivative method, two and three sample technique; Walsh function analysis- Least squares based methods, differential equation based techniques; Travelling wave protective schemes; FIR based algorithms; Least square curve fitting algorithm.

UNIT IV DIGITAL PROTECTION TECHNIQUES 9

Transformer protection; Fourier based algorithm - Basic hardware of microprocessor based transformer protection; Digital line differential scheme; Measurement algorithms for digital protection – Power, voltage, current, impedance, phase shift; Short window Wavelet based fault identification techniques-Sliding window, FWHT, signal analysis and synthesis; AC/DC cable fault location; Intrinsic and extrinsic fault; Harmonic filtering in fault analysis.

UNIT V DIGITAL PROTECTIVE RELAYS 9

Decision making in protective relays- Deterministic decision making; Statistical hypotheses testing; Decision making with multiple criteria; Adaptive decision schemes; Elements of fuzzy logic in protective relays, fuzzy sets and fuzzy numbers, Boolean versus fuzzy logic, fuzzy reasoning, fuzzy logic applications for protection and control.

TOTAL PERIODS 45

COURSE OUTCOMES

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

- apply DSP techniques for digital protection.
- make decision to implement suitable algorithm for digital relaying applications.
- employ FIR based algorithms for digital relaying.
- do transformer protection using digital techniques.
- perform coordinated operation of relays for specific purposes.

REFERENCES

1. J.L. Blackburn, "Protective Relaying: Principles and Applications", Marcel Dekker, New York, Seventh Edition 2016.
2. A.G. Phadke and J.S. Thorp, "Computer Relaying for Power Systems", John Wiley & Sons, New York, Reprint 2013.
3. J.G. Proakis and D.G. Manolakis, "Digital Signal Processing Principles, Algorithms", 2017.
4. Y.G. Paithankar and S.R Bhide, "Fundamentals of Power System Protection", PHI Learning, Second Edition Reprint 2018.

CO-PO MAPPING

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's (1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
CO's	Programme Outcomes PO's												PSO's	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	2	1	-	1	-	-	-	-	-	-	2	3	3
CO2	3	1	2	-	3	1	-	-	-	-	-	1	3	3
CO3	3	-	3	1	1	1	-	-	-	-	-	2	3	3
CO4	3	2	1	2	-	1	-	-	-	-	-	1	3	3
CO5	3	2	2	-	3	1	-	-	-	-	-	2	3	3

PPS23163 SCADA SYSTEM AND APPLICATION 3 0 0 3

COURSE OBJECTIVES

To enable the students to

- know about the functional requirements of SCADA.
- infer the system components of SCADA.
- understand the communication protocols used in SCADA.
- interpret the monitoring and control process of SCADA.
- identify the SCADA application in power system.

UNIT I INTRODUCTION TO SCADA 9

Evolution of SCADA, SCADA definitions, SCADA functional requirements and components, SCADA hierarchical concept, SCADA architecture, general features, SCADA applications, benefits.

UNIT II SCADA SYSTEM COMPONENTS 9

Remote terminal unit (RTU); Interface units - Human-machine interface units (HMI); Display monitors/data logger systems; Intelligent electronic devices (IED); Communication network, SCADA server, SCADA control systems and control panels.

UNIT III SCADA COMMUNICATION 9

SCADA communication requirements; Communication protocols - Past, present and future, structure of a SCADA communications protocol, comparison of various communication protocols; IEC61850 based communication architecture; Communication media - Fiber optic, PLCC; Interface provisions and communication extensions, synchronization with NCC and DCC.

UNIT IV SCADA MONITORING AND CONTROL 9

Online monitoring the event and alarm system, trends and reports, blocking list, event disturbance recording; Control function - Station control, bay control, breaker control and disconnector control.

UNIT V SCADA APPLICATIONS IN POWER SYSTEM 9

Applications in generation, transmission and distribution sector; Substation SCADA system - Functional description, system specification, system selection such as substation configuration; IEC61850 ring configuration; SAS cubicle concepts, gateway interoperability list, signal naming concept; System installation, testing and commissioning.

TOTAL PERIODS 45

COURSE OUTCOMES

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

- enumerate the functional requirements and architecture of SCADA.
- explain the various system components and control panels in SCADA.
- analyze the SCADA communication protocols.

- investigate the control and monitoring functions of SCADA.
- describe the SCADA application in power system.

REFERENCES

1. Stuart A. Boyer, "SCADA-Supervisory Control and Data Acquisition", Instrument Society of America Publications, USA, 2014.
2. Gordon Clarke, Deon Reynders, "Practical Modern SCADA Protocols: DNP3, 60870.5 and Related Systems", Newnes Publications, Oxford, UK, 2014.
3. William T. Shaw, "Cyber Security for SCADA systems", Penn Well Books, 2016.
4. David Bailey, Edwin Wright, "Practical SCADA for Industry", Newnes, 2018.

CO-PO MAPPING

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	Programme Outcomes PO's												PSO's	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	1	3	-	3	2	-	-	-	-	-	2	3	3
CO2	3	1	3	-	3	2	-	-	-	-	-	2	3	3
CO3	3	1	3	-	-	2	-	-	-	-	-	2	3	3
CO4	3	1	3	-	-	2	-	-	-	-	-	2	3	3
CO5	3	1	3	-	3	2	-	-	-	-	-	2	3	3

PPS23164 FACTS AND CUSTOM POWER DEVICES 3 0 0 3

COURSE OBJECTIVES

To enable the students to

- infer the basic concept of transmission systems and FACTS controllers.
- identify the suitable compensator and its control.
- review various series compensation techniques.
- know about unified power flow controller.
- understand the modelling of interline power flow controller.

UNIT I BASICS OF TRANSMISSION SYSTEM AND FACTS CONTROLLERS 9

Reactive power flow control in power systems; Control of dynamic power un-balances in power system; Power flow control; Constraints of maximum transmission line loading; Benefits of FACTS transmission line compensation; Uncompensated line -Shunt compensation, series compensation; Phase angle control; Reactive power compensation.- Shunt and series compensation principles, reactive compensation at transmission and distribution level.

UNIT II SVC AND STATCOM 9

Static versus passive VAR compensator; Static shunt compensators - SVC and STATCOM, operation and control of TSC, TCR and STATCOM, compensator control; Comparison between SVC and STATCOM.

UNIT III STATIC SERIES COMPENSATION 9

TSSC, SSSC; Static voltage and phase angle regulators; TCVR and TCPAR operation and control, applications; Static series compensation – GCSC, TSSC, TCSC and their control.

UNIT IV UNIFIED POWER FLOW CONTROLLER 9

SSR and its damping; Unified power flow controller - Circuit arrangement, operation and control of UPFC; Basic principle of P and Q control; Independent real and reactive power flow control, applications.

UNIT V INTERLINE POWER FLOW CONTROLLER 9

Introduction to interline power flow controller; Modeling and analysis of FACTS controllers; Simulation of FACTS controllers; Power quality problems in distribution systems, harmonics; Loads that create harmonics, modeling, harmonic propagation, series and parallel resonances, mitigation of harmonics, passive filters, active filtering; Shunt, series and hybrid and their control; Power quality issues - Voltage swells, sags, flicker, unbalance and mitigation of these problems by power line conditioners; IEEE standards on power quality.

TOTAL PERIODS 45

COURSE OUTCOMES

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

- distinguish the performance of transmission line with and without FACTS devices
- compare the SVC and STATCOM.
- describe the operation and control of various static series compensators.
- explain the operation and control of unified power flow controller.
- distinguish various power quality issues and how are they mitigated by various FACTS devices.

REFERENCES

1. K R Padiyar, "FACTS Controllers in Power Transmission and Distribution", New Age International Publishers, 2017.
2. N.G. Hingorani, L. Gyugyi, "Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems", IEEE Press Book, Standard Publishers and Distributors, Delhi, Reprint 2019.
3. X P Zhang, C Rehtanz, B Pal, "Flexible AC Transmission Systems- Modelling and Control", Springer Verlag, Berlin, Reprint 2017.
4. K.S.Suresh Kumar, S.Ashok, "FACTS Controllers & Applications", E-book edition, Nalanda Digital Library, NIT Calicut, 2016.

CO-PO MAPPING

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's (1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
CO's	Programme Outcomes PO's												PSO's	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	1	3	-	3	2	-	-	-	-	-	2	3	3
CO2	3	1	3	-	3	2	-	-	-	-	-	2	3	3
CO3	3	1	3	-	-	2	-	-	-	-	-	2	3	3
CO4	3	1	3	-	-	2	-	-	-	-	-	2	3	3
CO5	3	1	3	-	3	2	-	-	-	-	-	2	3	3

PPS23165 COMPUTER RELAYING AND WIDE AREA MEASUREMENT SYSTEMS 3 0 0 3

COURSE OBJECTIVES

To enable the students to

- discriminate conventional relays and computer relays.
- comprehend the operating values of a computer relays.
- provide exposure to wide area measurement systems through the computer hierarchy in the substation, system relaying and control.
- inculcate knowledge on phasor measurement unit and its application to power system.
- enhance the conventional power system studies with wide area measurement techniques.

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 - Phasor measurement units, 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 PERIODS 45

COURSE OUTCOMES

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

- demonstrate knowledge of fundamental theories, principles and practice of computer relaying, wide area measurement system.
- analyze the power system with computer relaying and wide area measurement system.
- validate the recent relaying technologies which work towards smart grid.
- design wide area measurement systems for smart grid.
- 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, Second Edition, Reprint 2019.
2. A.G. Phadke, J.S. Thorp, "Synchronized Phasor Measurements and Their Applications", Springer, First Edition, Reprint 2018.
3. Antonello Monti, Carlo Muscas, FerdinandaPonci, "Phasor Measurement Units and Wide Area Monitoring Systems" Academic Press, 2016.
4. Stanley H. Horowitz, Arun G. Phadke, "Power System Relaying", John Wiley & Sons, 2013.

CO-PO MAPPING

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's (1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
CO's	Programme Outcomes PO's												PSO's	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	-	-	-	3	-	-	-	-	-	-	2	3	3
CO2	3	1	2	-	3	3	-	-	-	-	-	2	3	3
CO3	3	1	2	-	2	3	-	-	-	-	-	2	3	3
CO4	3	1	1	-	2	3	-	-	-	-	-	2	3	3
CO5	3	1	2	-	3	3	-	-	-	-	-	2	3	3

PPS23166 ENERGY MANAGEMENT AND AUDITING 3 0 0 3

COURSE OBJECTIVES

To enable the students to

- understand the present energy scenario and role of energy managers.
- comprehend the economic models for cost and load management.
- configure the demand side energy management through its control techniques, strategy and planning.
- understand the process of energy auditing.
- know energy conservation aspects in industries.

UNIT I ENERGY SCENARIO 9

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

UNIT II ENERGY COST AND LOAD MANAGEMENT 9

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

UNIT III ENERGY MANAGEMENT 9

Demand side management (DSM) - DSM planning, DSM techniques, load management as a DSM strategy; Energy conservation; Tariff options for DSM.

UNIT IV ENERGY AUDITING 9

Definition; Energy audit methodology - Audit preparation, execution and reporting; Financial analysis, sensitivity analysis, project financing options; Instruments for energy audit; Energy audit for generation, distribution and utilization systems; Economic analysis.

UNIT V ENERGY EFFICIENT TECHNOLOGIES 9

Energy saving opportunities in electric motors - Power factor improvement benefit and techniques; Shunt capacitor, synchronous condenser and phase advancer; Energy conservation in industrial drives, electric furnaces, ovens and boilers; Lighting techniques - Natural, CFL, LED lighting sources and fittings.

TOTAL PERIODS 45

COURSE OUTCOMES

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

- identify the energy policy and roles of energy managers.
- enumerate the cost and load management on economic models.

- explain the energy management on demand side.
- describe the process of energy auditing.
- implement energy conservation aspects in industries.

REFERENCES

1. Barney L. Capehart, Wayne C. Turner, William J. Kennedy, "Guide to Energy Management", CRC press, Taylor & Francis group, Eighth Edition, 2016.
2. Eastop T.D and Croft D.R, "Energy Efficiency for Engineers and Technologists", Logman Scientific & Technical, Fifth Edition, Reprint 2017.
3. Anil Kumar, Om Prakash ,Chauhan Prashant Singh. "Energy Management: Conservation and Audits", CRC Press, 2020.
4. Barney L. Capehart, Wayne C. Turner, William J. Kennedy, "Guide to Energy Management", CRC press, Taylor & Francis group, Eighth Edition, 2016.

CO-PO MAPPING

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	Programme Outcomes PO's												PSO's	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	2	2	2	-	2	-	-	-	-	-	-	2	3	3
CO2	2	2	2	1	2	1	-	-	-	-	-	2	3	3
CO3	2	3	2	1	2	2	-	-	-	-	-	2	3	3
CO4	1	2	2	3	-	-	-	-	-	-	-	2	3	3
CO5	3	2	2	3	3	3	-	-	-	-	-	2	3	3

PAAVAI ENGINEERING COLLEGE, NAMAKKAL
Approved
BOARD OF STUDIES
Electrical & Electronics Engineering
28/6/23
AUTONOMOUS