PAAVAI ENGINEERING COLLEGE(AUTONOMOUS)

REGULATIONS – 2016
PG CURRICULUM
CHOICE BASED CREDIT SYSTEM
(For the candidate's admitted during the academic year 2016-2017)

M.E.- POWER SYSTEMS ENGINEERING						
SEMESTER I						
S.No	**Course Code**	**Course Title**	**L**	**T**	**P**	**C**
Theory						
1	PMA16105	Applied Mathematics for Electrical Engineers	3	2	0	4
2	PPS16101	Advanced Power System Analysis	3	2	0	4
3	PPS16102	Power System Operation and Control	3	2	0	4
4	PPS16103	Modern Power System Protection	3	0	0	3
5	PPS16104	EHV AC Transmission Engineering	3	0	0	3
6	PP*1615*	Elective I	3	0	0	3
Practical						
7	PPS16105	Power Systems Simulation Laboratory I	0	0	4	2
8	PPS16106	Technical Seminar I	0	0	2	1
		TOTAL	**18**	**6**	**6**	**24**
SEMESTER II						
Theory						
1	PPS16201	Flexible AC Transmission Systems	3	2	0	4
2	PPS16202	Power System Dynamics	3	0	0	3
3	PPS16203	Power System Economics	3	0	0	3
4	PPS16204	Power System Transients and Surge Protection	3	0	0	3
5	PP*1625*	Elective II	3	2	0	4
	PP*1635*	Elective III	3	0	0	3
Practical						
7	PPS16205	Power System Simulation Laboratory II	0	0	4	2
8	PPS16206	Technical Seminar II	0	0	2	1
		TOTAL	**18**	**4**	**6**	**23**
LIST OF ELECTIVES						
ELECTIVE I						
1	PPE16151	Analysis of Inverters	3	0	0	3
2	PPS16152	Power System Security	3	0	0	3
3	PPS16153	Linear and Non-Linear System Theory	3	0	0	3

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ELECTIVE II						
1	PPS16251	High Voltage Direct Current Transmission	3	0	0	3
2	PPS16252	Power Quality Analysis	3	0	0	3
3	PPE16253	Electrical Grounding	3	0	0	3
ELECTIVE III (OPEN ELECTIVE)						
1	PPS16351	Energy Auditing and Management	3	0	0	3
2	PPS16352	Artificial Intelligence and its Application	3	0	0	3

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SEMESTER I

PMA16105 APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERS 3 2 0 4

COURSE OBJECTIVES

- To develop the ability to apply the concepts of matrix theory and linear programming in electrical engineering problems.
- To familiarize the students in calculus of variations and solve problems using fourier transforms associated with engineering applications
- To understand the basic concepts of one dimensional random variables and apply in electrical engineering problems
- To formulate and construct a mathematical model for a linear programming problem in real life situation
- To introduce fourier series analysis which is central to many applications in engineering apart from its use in solving boundary value problems

UNIT I MATRIX THEORY 15

The Cholesky decomposition – Generalized Eigenvectors, Canonical basis – QR factorization – Least square method – Singular value decomposition.

UNIT II CALCULUS OF VARIATIONS 15

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

UNIT III ONE DIMENSIONAL RANDOM VARIABLES 15

Random variables – Probability function – moments – moment generating functions and their properties – Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions – Function of a Random Variable.

UNIT IV LINEAR PROGRAMMING 15

Formulation – Graphical solution – Simplex method – Two phase method – Transportation and Assignment Models.

UNIT V FOURIER SERIES 15

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

TOTAL: 75 PERIODS

COURSE OUTCOMES

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

- gain a well found knowledge in matrix to calculate the electrical properties of a circuit, with voltage, amperage ,resistance, etc.
- solve a variational problem using the Euler equation.
- gain knowledge in standard distributions which can describe the real life phenomena.

- understand and apply linear, integer programming to solve operational problem with constraints.
- apply fourier series, their different possible forms and the frequently needed practical harmonic analysis.

REFERENCES

1. Richard Bronson, ―Matrix Operation‖, Schaum's outline series, 2nd Edition, McGraw Hill, 2011.
2. Gupta, A.S., ―Calculus of Variations with Applications‖, Prentice Hall of India Pvt. Ltd., New Delhi, 1997.
3. Oliver C. Ibe, ―Fundamentals of Applied Probability and Random Processes‖, Academic Press, (An imprint of Elsevier), 2010.
4. Taha, H.A., ―Operations Research, An introduction‖, 10th edition, Pearson education, New Delhi, 2010.
5. Andrews L.C. and Phillips R.L., ―Mathematical Techniques for Engineers and Scientists‖, Prentice Hall of India Pvt.Ltd., New Delhi, 2005.
6. Elsgolts, L., ―Differential Equations and the Calculus of Variations‖, MIR Publishers, Moscow, 1973.
7. Johnson R. A. and Gupta C. B., ―Miller & Freund's Probability and Statistics for Engineers‖, Pearson Education, Asia, 7th Edition, 2007.

WEB LINKS

1. https://www.youtube.com/watch?v=8xsi296A9Co
2. https://www.youtube.com/watch?v=35UmpC6nrg8
3. https://www.youtube.com/watch?v=WWv0RUxDfbs
4. https://www.youtube.com/watch?v=8VgmBe3ulb8
5. https://www.youtube.com/watch?v=M8POtpPtQZc

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	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	3	-	1	-	-	2	-	-	3	2	1
CO2	3	3	3	3	-	1	-	-	2	-	-	3	2	1
CO3	3	3	3	3	-	1	-	-	2	-	-	3	2	1
CO4	3	3	3	3	-	1	-	-	2	-	-	3	2	1
CO5	3	3	3	3	-	1	-	-	2	-	-	3	2	1

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Mathematics
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PPS16101 ADVANCED POWER SYSTEMS ANALYSIS 3 2 0 4

COURSE OBJECTIVES

- To analyse the mathematical representation of power system components and solution techniques.
- To generalise the power flow analysis using various methods.
- To produce the optimal power flow solutions by using newton's method, gradient method, LP methods.
- To infer knowledge of the different types of faults and its calculation using computer method and mathematical model.
- To apply knowledge in the concept of numerical integration methods to analyse power system transient stability.

UNIT I SOLUTION TECHNIQUES 15

Sparse Matrix techniques for large scale power systems: Optimal ordering schemes for preserving sparsity.Flexible packed storage scheme for storing matrix as compact arrays – Factorization by Bifactorization and Gauss elimination methods; Repeat solution using Left and Right factors and L and U matrices.

UNIT II POWER FLOW ANALYSIS 15

Fast Decoupled Power Flow method; Sensitivity factors for P-V bus adjustment; Net Interchange power control in Multi-area power flow analysis: ATC, Assessment of Available Transfer Capability (ATC) using Repeated Power Flow method; Continuation Power Flow method; Contingency Analysis.

UNIT III OPTIMAL POWER FLOW 15

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

UNIT IV SHORT CIRCUIT ANALYSIS 15

Fault calculations using sequence networks for different types of faults. Bus impedance matrix (ZBUS) construction using Building Algorithm for lines with mutual coupling; Simple numerical problems. Computer method for fault analysis using ZBUS and sequence components. Derivation of equations for bus voltages, fault current and line currents, both in sequence and phase domain usingThevenin's equivalent and ZBUS matrix for different faults.

UNIT V TRANSIENT STABILITY ANALYSIS 15

Introduction, Numerical Integration Methods: Euler and Fourth Order Runge-Kutta methods, Algorithm for simulation of SMIB and multi-machine system with classical synchronous machine model; Factors influencing transient stability, Numerical stability and implicit Integration methods.

TOTAL: 75 PERIODS

COURSE OUTCOMES

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

- design proper mathematical models for analysis of power system components.
- understand the methodologies of power flow studies for the power system network.
- produce the optimal solutions for power flow problems.
- evaluate the short circuit problems prevailing in power systems.
- prepare numerical integration methods to analyze power system transient stability.

REFERENCES

1. Grainger, J.D., ―Power System Analysis‖, Tata McGraw Hill Publishing Company, 2008.
2. Kusic, C.L., ―Computer Aided Power System Analysis‖, Tata McGraw Hill PublishingCompany, 2001.
3. Pai, M. A., ―Computer Techniques in Power System Analysis‖, TMH Publishing Company,2003.
4. Stagg, G. W. and Elabiad, A. H., ―Computer Methods in Power System Analysis‖, McGrawHill, 2010.
5. Wood, A.J. and Wollenberg, B.F., ―Power Generation, Operation and Control‖, John Wiley and Sons, 2013.
6. Singh L.P., ―Advanced power system analysis and dynamics‖, 3rd Ed., Wiley eastern, NewDelhi, 2012.

WEB LINKS

1. media.johnwiley.com.au/product_data/excerpt/59/.../0471790559-4.pdf
2. dl.lib.mrt.ac.lk/bitstream/handle/123/1748/92960_Post-text.pdf.
3. www.kandrfarms.com/.../power-system-analysis-by-grainger-and-stevens.

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CO's	Programme Outcomes PO's												PSO's	
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CO1	3	3	3	2	3	1	-	1	-	2	-	2	2	3
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CO3	3	3	3	2	3	1	-	1	-	2	-	2	2	3
CO4	3	3	3	2	3	1	-	1	-	2	-	2	2	3
CO5	3	3	3	2	3	1	-	1	-	2	-	2	2	3

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PPS16102 POWER SYSTEM OPERATION AND CONTROL 3 2 0 4

COURSE OBJECTIVES

- To understand the modelling and analysis of various controlling techniques for single machine and multi machine systems.
- To describe the AVR control for single-machine infinite bus system and multi machine power systems.
- To explain the optimum generation allocation and the economic dispatch for energy management concepts in power system engineering.
- To infer knowledge in the effective implementation of coordinated hydro thermal power systems.
- To apply knowledge for finding the least-cost dispatch of available generation resources to meet the electrical load.

UNIT I LOAD FREQUENCY CONTROL 15

Introduction, Modelling of ALFC control loop, biased control, concept of multi-area control, tie line bias control, Mathematical models of various turbine-governor systems, stability analysis of single area and multi area systems, transient stability analysis of multi-machine system.

UNIT II AVR CONTROL 15

Mathematical model of AVR control loop, modeling of various excitation systems, stability analysis of AVR systems, Lag-Lead compensation, cross coupling between AVR and ALFC control loops. Concept of AVR in multi-machine system, concept of reactive power and voltage dependency, voltage stability analysis of single machine infinite bus system.

UNIT III OPTIMAL GENERATION DISPATCH 15

Input output characteristics of a power generation units, optimum generation allocation of thermal units with and without losses, derivation of transmission loss formula, Reactive power dispatch, environmental economic dispatch, optimal dispatch of hydro units.

UNIT IV HYDRO THERMAL COORDINATION 15

Advantages of coordination, optimal scheduling of hydrothermal system, short term, long term and stochastic hydro-thermal scheduling, combined working of runoff river plant with steam plant, Multi-reservoir plant, Pumpedstorage hydro plants.

UNIT V UNIT COMMITMENT 15

Optimal Unit commitment, constraints in UC: spinning reserve, thermal unit constraints, hydro constraints, fuel constraints and other constraints; UC solution methods: Priority-list methods, Solution to unit commitment by dynamic programming, effect of start-up and shut down time/cost, optimal unit commitment with security.

TOTAL: 75 PERIODS

COURSE OUTCOMES

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

- design and relate the single and multi-machine systems.
- apply AVR control in single-machine infinite bus system and multi machine systems.
- label the power systems pertaining to economic dispatch for energy management concepts.
- use the coordinated hydro thermal power systems effectively.
- rewrite the dispatch of available generation resources to meet the electrical load demand.

REFERENCES

1. Wood, A.J. and Wollenberg, B.F., ―Power Generation, Operation and Control‖, John Wiley and Sons, 2013.
2. Kothari, D.P., Dhillon J.S. ―Power system Optimisation‖, 2nd Ed., PHI, 2011.
3. Elgerd O.I., ―Electric Energy System Theory- An Introduction‖, McGraw-Hill, 2012.
4. P. Kundur, ―Power System Stability & Control‖ Tata McGraw Hill, 2007.

WEB LINKS

1. media.johnwiley.com.au/product_data/excerpt/59/.../0471790559-4.pdf
2. www.newagepublishers.com/samplechapter/001758.pdf
3. www.unge.gq/ftp/biblioteca%20digital/.../Estabilidad%20-%20kundur.pdf.

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CO1	3	2	3	2	3	1	-	1	-	2	-	2	3	3
CO2	3	2	3	2	3	1	-	1	-	2	-	2	3	3
CO3	3	2	3	2	3	1	-	1	-	2	-	2	3	3
CO4	3	2	3	2	3	1	-	1	-	2	-	2	3	3
CO5	3	2	3	2	3	1	-	1	-	2	-	2	3	3

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PPS16103 MODERN POWER SYSTEM PROTECTION 3 0 0 3

COURSE OBJECTIVES

- To apply the characteristics and functions of relays and protection schemes.
- To illustrate the concepts of transformer protection and generator protection in faulty conditions.
- To analyse the usage of relays in distance and carrier protection for single and double end fed lines.
- To examine the concepts of busbar protection under various fault conditions using current transformer.
- To describe the various schemes of static comparators and analysis of numerical protection.

UNIT I INTRODUCTION 9

Zones of protection – Primary and Backup protection – operating principles and Relay Construction -time – current characteristics-Current setting – Time setting-Over current protective schemes -Reverse power or directional relay - Protection of parallel feeders - Protection of ring feeders – Earth fault and phase fault protection - Combined Earth fault and phase fault protection scheme – Phase fault protective scheme directional earth fault relay - Static over current relays.

UNIT II EQUIPMENT PROTECTION 9

Types of transformers – Phasor diagram for a three phase transformer-Equivalent circuit of transformer – Types of faults in transformers- Over current protection Percentage Differential Protection of Transformers - Inrush phenomenon- High resistance Ground Faults in Transformers –Inter turn faults in transformers – Incipient faults in transformers - Phenomenon of over fluxing in transformers – Transformer protection application chart .Generator protection: Electrical circuit of the generator – Various faults and abnormal operating conditions- Stator faults- Rotor faults –Abnormal operating conditions. Induction Motor protection: Electrical Faults-Abnormal Operating Conditions from Supply side.

UNIT III DISTANCE AND CARRIER PROTECTION OF TRANSMISSION LINES 9

Introduction to distance relay – Simple impedance relay – Reactance relay – mho relays- Distance protection of a three Phase line - Three stepped distance protection - Trip contact configuration for the three - Stepped distance protection - Three-stepped protection of three-phase line against alltenshunt faults - Three-stepped protection of double end fed lines - Various options for a carrier – Coupling and trapping the carrier into the desired line section - Unit type carrier aided directional comparison relaying – Carrier aided distance schemes for acceleration of zone II- Phase Comparison Relaying.

UNIT IV BUSBAR PROTECTION 9

Introduction – Differential protection of busbars-external and internal fault – Actual behaviors of a protective CT - Circuit model of a saturated CT - External fault with one CT saturation need for high impedance – Minimum internal fault that can be detected by the high impedance Bus bar differential scheme – Stability ratio of high impedance busbar differential scheme - Supervisory relay-protection of three Phase busbars.

UNIT V STATIC COMPARATOR AS A RELAY AND NUMERICAL PROTECTION 9

Amplitude Comparator- Phase Comparator- Duality between Amplitude and Phase Comparator Introduction-Synthesis of Various distance Relay using Static Comparator. Numerical Protection: Block diagram of numerical relay - Sampling theorem- Correlation with a reference wave – Least error squared (LES) technique - numerical over Current protection – Numerical transformer differential protection-Numerical distance protection of transmission line.

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

- summarize the construction and operation of electromagnetic relays.
- choose the protective circuit based on the knowledge of faults in equipment.
- analyse the usage of relays in distance and carrier protection for single and double end fed lines.
- understand the effective usage of CT in protection circuits.
- perform synthesis of numerical protection of transmission line using static comparator.

REFERENCES

1. Ravindar P. Singh, ―Digital Power System Protection‖, PHI, New Delhi, 2007.
2. T.S.M.Rao, ―Digital / Numerical Relays‖, Tata McGraw Hill, 2005.
3. Y.G.Paithankar, S.R.Bhide, ―Fundamentals of Power System Protection‖, Prentice – Hall India, 2004.
4. L.P.Singh, ―Digital protection, Protective Relaying from Electromechanical to Microprocessor‖, John Wiley & Sons, 1995.

WEB LINKS

1. my.mmosite.com/.../fundamentals_of_power_system_protection_pdf.ht.
2. www.spendbooks.org/1jw7fr_ebooks-digital-numerical-relays.pdf
3. www.egully.com/.../SWITCHGEAR-%26-POWER-SYSTEM-PROTECTION.

CO-PO MAPPING:

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CO1	3	-	3	2	3	1	-	1	-	2	-	2	-	2
CO2	3	-	3	2	3	1	-	1	-	2	-	2	-	2
CO3	3	-	3	2	3	1	-	1	-	2	-	2	-	2
CO4	3	-	3	2	3	1	-	1	-	2	-	2	-	2
CO5	3	-	3	2	3	1	-	1	-	2	-	2	-	2

PPS16104 EHV AC TRANSMISSION ENGINEERING 3 0 0 3

COURSE OBJECTIVES

- To gain knowledge in the different aspects of design and analysis of EHV A.C transmission systems.
- To understand the analysis of various transmission line parameters.
- To infer knowledge on the impact of voltage gradients in conductors.
- To evaluate the different types of losses caused by corona effect.
- To acquire knowledge in the effects of electrostatic field in EHV AC transmission system.

UNIT I TRANSMISSION ENGINEERING 9

Necessity of EHV AC transmission. Standard transmission voltages, average values of line parameters, Power handling capacity and line loss, examples of giant power pools and number of lines, costs of transmission lines and equipment, mechanical considerations in line performance.

UNIT II CALCULATION OF LINE RESISTANCE AND INDUCTANCES 9

Resistance of conductors, temperature rise of conductor and current carrying capacity. Properties of bundled conductors and geometric mean radius of bundle, inductance of two conductor lines and multi – conductor lines.

UNIT III VOLTAGE GRADIENTS OF CONDUCTOR 9

Electrostatics – field of sphere gap, charge-potential relations for multi-conductor lines – surface voltage gradient on conductors –gradient factors and their use – distribution of voltage gradient on sub conductors of bundle – voltage gradients on conductors in the presence of ground wires on towers.

UNIT IV CORONA EFFECTS 9

Power loss and audible noise (AN) – corona loss formulae – charge voltage diagram – generation, characteristics – limits and measurements of AN – relation between 1-phase and 3-phase AN levels – Radio interference (RI) – corona pulses generation, properties, limits – frequency spectrum – modes of propagation – excitation function – measurement of RI, RIV and excitation functions

UNIT V ELECTROSTATIC FIELD OF EHV LINES 9

Effect of EHV line on heavy vehicles - calculation of electrostatic field of AC lines- effect of high field on humans, animals, and plants- measurement of electrostatic fields - electrostatic Induction in unenergised circuit of a D/C line - induced voltages in insulated ground wires – electromagnetic interference.

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

- understand the necessity of EHV AC transmission, choice of voltage for transmission line losses and power handling capability.
- analyze the statistical procedures for line designs, scientific and engineering principles in power systems.
- assess the distribution of voltage gradients on conductors.
- evaluate the losses encountered due to corona effect.
- examine the effects due to the electrostatic field in EHV AC transmission system.

REFERENCES

1. Rakosh Das Bagamudre, ―Extra High Voltage AC Transmission Engineering‖, Wiley Eastern Ltd., New Delhi, 2013.
2. Allan Greenwood, ―Electrical Transients in Power Systems‖, John Wiley and Sons New York, 2012.
3. C.L.Wadhwa, ―Electrical Power Systems‖, New Age International (P) Ltd Publishers, 2015.
4. S.Rao –EHVAC and HVDC Transmission Engg. Practice‖ Khanna publishers.
5. Arrillaga.J ―High Voltage Direct Current Transmission‖ 2nd Edition (London) peter Peregrines, IEEE, 1998.

WEB LINKS

1. www.faadooengineers.com/.../24501-Extra-HIgh-voltage-AC-Transmission
2. https://www.scribd.com/.../Electrical-Transients-in-Power-Systems
3. www.faadooengineers.com/.../9550-Power-System-book-by-C-L-Wadhw

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	
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CO1	3	-	3	-	2	1	-	-	-	-	2	1	1	1
CO2	3	-	3	-	2	1	-	-	-	-	2	1	1	1
CO3	3	-	3	-	2	1	-	-	-	-	2	1	1	1
CO4	3	-	3	-	2	1	-	-	-	-	2	1	1	1
CO5	3	-	3	-	2	1	-	-	-	-	2	1	1	1

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Electrical & Electronics Engineering
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PPS16105 POWER SYSTEM SIMULATION LABORATORY I 0 0 4 2

COURSE OBJECTIVES

- know the power systems analysis in power system simulation software.
- understand the basics of design aspects of EMTP, single machine-infinite bus system and contingency analysis.
- use the economic dispatch and unit commitment programming.
- implement relay coordination

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: 60 PERIODS

COURSE OUTCOMES

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

- simulate and implement the power systems analysis in power system simulation software.
- design EMTP, single machine-infinite bus system and contingencyanalysis.
- Utilize the economic dispatch and unit commitment programming.
- implement relay coordination

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CO3	3	-	3	-	3	1	-	-	2	1	-	2	3	3
CO4	3	-	3	-	3	1	-	-	2	1	-	2	3	3

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PPS16106 **TECHNICAL SEMINAR I** **0 0 2 1**

COURSE OBJECTIVES

- To help students to acquire wide knowledge in the communication and the presentation skills in their technical papers.
- To strengthen their prospects of success in technical presentation.
- To enhance leadership quality.
- To Progress Employability

In this course, every student has to present at least two technical papers on recent advancements in engineering/technology referring journal papers and will be evaluated by the course instructor. During the seminar session, each student is expected to present a topic, for duration of about 15 to 20 minutes which will be followed by a discussion for 5 minutes. Each student is responsible for selecting a suitable topic that has not been presented previously. Every student is expected to participate actively in the ensuing class discussion by asking questions and providing constructive criticism.

TOTAL: 30 PERIODS

COURSE OUTCOMES

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

- communicate effectively.
- prepare quality and focused presentation.
- be the successful student researchers.
- success in employment

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CO2	3	-	-	-	-	2	1	2	3	3	1	3	1	-
CO3	3	-	-	-	-	2	1	2	3	3	1	3	1	-
CO4	3	-	-	-	-	2	1	2	3	3	1	3	1	-

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SEMESTER II

PPS16201 FLEXIBLE AC TRANSMISSION SYSTEMS 3 2 0 4

COURSE OBJECTIVES

- To understand the concepts of transient stability and voltage stability
- To infer knowledge on STATCOM and DSTATCOM.
- To explain the modeling and multifunction models of SSSC.
- To discuss various aspects of unified power flow controller and its characteristics.
- To describe the various thyristor controlled capacitors

UNIT I INTRODUCTION 15

Concept of reactive power compensation, Review of series and shunt compensation, Concepts of transient stability and voltage stability, Power system oscillations. Basic types of FACTS controllers, benefits from FACTS controllers.

UNIT II SHUNT COMPENSATORS 15

Mid point voltage regulation, Method of controlled VAR generation, principle of operation, Control and characteristics of SVC and STATCOM, Multi-control functional model of STATCOM for power flow analysis, Implementation of STATCOM models in Newton power flow, STATCOM in optimal power flow (OPF), STATCOM in distribution system (DSTATCOM), DSTATCOM performance in various modes including harmonic mitigation

UNIT III SERIES COMPENSATORS 15

Series compensation and voltage stability, Variable impedance type series compensators (TCSC) and switching converter type series converter (SSSC), Configurations, Control and characteristics, General applications, Modelling of multicontrol functional model of SSSC in power flow analysis, Implemetation of SSC models in Newton power flow, SSSC in OPF, Dynamic Voltage Restorer (DVR) in Distribution System, Subsynchronous Resonance Problem, NGH Scheme

UNIT IV UNIFIED POWER FLOW CONTROLLERS 15

Objectives and principle of operation of voltage and phase angle regulations, Static phase shifter and its operating characteristics**,** Unified Power Flow Controller (UPFC) control and characteristics, UPFC as generalised SSSC, Modelling of UPFC for power flow and OPF studies, Implementing UPFC in Newton power flow, Power oscillations control with UPFC.

UNIT V INTERLINE POWER FLOW CONTROLLER AND CO-ORDINATION OF FACTS CONTROLLERS 15

Principle of operation, Control and characteristics, Model of IPFC for power flow and optimum power flow studies. FACTS Controller interactions – SVC–SVC interaction, SVC-TCSC interaction, TCSC-TCSC interaction and SSSC – STATCOM interaction.

TOTAL: 75 PERIODS

COURSE OUTCOMES

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

- know the basic concepts of compensation in FACTS controller.

- understand the issues of damping to power system oscillations, real and reactive power control.
- understand the characteristics and configuration series compensators.
- compare UPFC with controlled series compensators and phase shifter.
- demonstrate the concepts of interline power flow controller and co-ordination of FACTS controllers.

TEXT BOOKS

1. Song, Y.H. and Johns, A.T., Flexible AC Transmission Systems, IEEE Press (1999).
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3. Mathur, R.M. and Verma, R.K., Thyristor based FACTS controllers for Electrical Transmission Systems, IEEE Press (2002).
4. Zhang, X. P., Rehtanz, C. and Pal, B., Flexible AC Transmission Systems: Modelling and Control, Springer (2006).

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2. https://www.ee.iitb.ac.in/~npsc2008/NPSC_CD/Data/Oral/.../p236.pdf
3. new.abb.com › Offerings › FACTS

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	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	-	-	3	2	-	-	-	-	1	2	3	3
CO2	3	2	-	-	3	2	-	-	-	-	1	2	3	3
CO3	3	2	-	-	3	3	-	-	-	-	1	2	3	3
CO4	3	2	-	-	3	2	-	-	--	-	1	2	3	3
CO5	3	2	-	-	3	3	-	-	-	-	1	2	3	3

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PPS16202 POWER SYSTEM DYNAMICS 3 0 0 3

COURSE OBJECTIVES

- To explain the basics of mathematical description of a synchronous machine.
- To acquire knowledge in speed governing systems.
- To understand the concepts of system stability analysis with and without controllers.
- To deduce the stability and instability analysis of various power system networks.
- To analyse the digital simulation of various energy functions.

UNIT I SYNCHRONOUS MACHINE MODELING 9

Synchronous Machine - Physical Description - Mathematical Description of a Synchronous Machine - Basic equations of a synchronous machine - stator circuit equations, stator self, stator mutual and stator to rotor mutual inductances - dq0 Transformation - Per Unit Representation - Equivalent Circuits for direct and quadrature axes - Steady-state Analysis - Steady-state equivalent circuit, Computation of steady-state values Equations of Motion - Swing Equation, H-constant calculation - Representation in system studies - Synchronous Machine Representation in Stability Studies - Simplified model with amortisseurs neglected: - classical model withamortisseurwindings neglected.

UNIT II MODELING OF EXCITATION AND SPEED GOVERNING SYSTEMS 9

Excitation System Modeling - Excitation System Requirements - Types of Excitation System - Rotating Rectifier and Potential-source controlled-rectifier systems: hardware block diagram and IEEE(1992) Type ST1A block diagram. Turbine and Governing System Modeling: Functional Block Diagram of Power Generation and Control - Schematic of a hydroelectric plant - classical transfer function of a hydraulic turbine (no derivation) - special characteristic of hydraulic turbine - electrical analogue of hydraulic turbine Governor for Hydraulic Turbine - Requirement for a transient droop, Block diagram of governor with transient droop compensation - Steam turbine modeling: Single reheat tandem compounded type only and IEEE block diagram for dynamic simulation; geneneric speed-governing system model for normal speed/load control function.

UNIT III SMALL-SIGNALS STABILITY ANALYSIS WITH AND WITHOUT CONTROLLERS 9

Classification of Stability - Basic Concepts and Definitions: Rotor angle stability - Fundamental Concepts of Stability of Dynamic Systems: State-space representation - stability of dynamic system - Linearization, Eigen properties of the state matrix – Eigenvalue and stability - Single-Machine Infinities Bus (SMIB) Configuration: Classical Machine Model stability analysis with numerical example - Effect of field flux variation on system stability: analysis with numerical example -Effects of Excitation System - analysis of effect of AVR on synchronizing and damping components using a numerical example - Multi-Machine Configuration - Equations ina common reference frame - Formation of system state matrix for a two-machine system with classical models for synchronous machines, illustration of stability analysis using a numerical example.

UNIT IV TRANSIENT STABILITY ANALYSIS 9

Introduction - Factors influencing transient stability – Review of Numerical Integration Methods - Simulation of Power System Dynamic response: Structure of Power system Model, Synchronous machine representation - Thevenin's and Norton's equivalent circuits, Excitation system representation, Transmission network and load representation, Overall system equations and their solution: Partitioned - explicit and Simultaneous-implicit approaches, treatment of discontinuities, Simplified Transient Stability Simulation using simultaneous-implicit approaches.

UNIT V INSTABILITY ANALYSIS 9

Small signal angle instability (sub-synchronous frequency oscillations): analysis and counter-measures. Transient Instability: Analysis using digital simulation and energy function method. Transient stability controllers. Introduction to voltage Instability. Analysis of voltage Instability.

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

- understand the fundamental dynamic behavior of power systems.
- control the power systems to perform basic stability analysis.
- summarize the concepts in modeling and simulating the dynamic phenomena of power systems.
- interpret results of system stability studies.
- demonstrate theory and practice of modeling main power system components, such as synchronous machines, excitation systems and governors.

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1. P. S. Kundur, ―Power System Stability and Control‖, McGraw-Hill, 2012.
2. K.R.Padiyar, ―Power System Dynamics Stability & Control‖, BS Publications, 2004.
3. P.M Anderson and A.A Fouad, –Power System Control and Stability‖, Iowa State University Press, 2008.
4. PeterW.Sauer&M.A.Pai, –Power System Dynamics & Stability‖, Pearson Education, 2002.
5. IEEE Committee Report, ―Dynamic Models for Steam and Hydro Turbines in Power System Studies,‖ IEEE Transactions, Vol.PAS-92, pp 1904-1915, November / December 1997.

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2. www.solvina.se/wp.../04/Power_System_Stability_Sweden_20132.pdf
3. ebitik.azerblog.com/anbar/3194.pdf

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

	Programme Outcomes PO's												PSO's	
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CO3	3	2	3	-	2	1	-	-	-	-	2	1	2	1
CO4	3	2	3	-	2	1	-	-	-	-	2	1	2	1
CO5	3	2	3	-	2	1	-	-	-	-	2	1	2	1

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PPS16203 POWER SYSTEM ECONOMICS 3 0 0 3

COURSE OBJECTIVES

- To impart basic knowledge in the power system restructuring, market structure, relation between demand and supply costs and electricity price
- To know basic ideas of factors affecting the electricity price in the restructured market and generation capacity valuation.
- To provide basic concepts and an overview of transmission price and distributed generation in restructured markets
- To give ideas of reactive power requirements under voltage stability studies, impact of reactive power in power tariff and the requirements of the utilities.
- To know the methods of plant location and equipment selection.

UNIT I POWER SECTOR ECONOMICS AND REGULATION 9

Typical cost components and cost structure of the power sector, Different methods of comparing investment options, Concept of life cycle cost , annual rate of return , methods of calculations of Internal Rate of Return(IRR) and Net Present Value(NPV) of project, Short term and long term marginal costs, Different financing options for the power sector . Different stakeholders in the power sector, Role of regulation and evolution of regulatory commission in India, types and methods of economic regulation, regulatory process in India.

UNIT II ELECTRICITY PRICE 9

Price volatility, ancillary services in electricity power market, automatic generation control and its pricing, Generation assets valuation and risk analysis. Introduction, VAR for Generation Asset Valuation, Generation Capacity Valuation.

UNIT III TRANSMISSION CONGESTION MANAGEMENT AND PRICING 9

Introduction of Transmission Congestion Management and Pricing- transmission cost allocation methods, LMP, FTR and Congestion Management. Role of FACTS devices in competitive power market, Available Transfer Capability, Distributed Generation in restructured markets.

UNIT IV REACTIVE POWER REQUIREMENTS 9

Reactive power requirements under steady state voltage stability and dynamic voltage stability, reactive power requirements to cover transient voltage stability, System losses and loss reduction methods, Power tariffs and Market Forces shaping of reactive power, reactive power requirement of the utilities.

UNIT V POWER ECONOMICS 9

Selection of plant: Plant capacity, Capacity Probability analysis, Plant location, equipment selection, Equipment cost – Station performance and operation characteristics – Specific economic energy problems: Steam plant, Hydraulic plant Interconnections – Energy rates.

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

- understand the basic concept in power sector economics and regulation
- infer knowledge in electricity price and generation asset valuation

- understand the role of FACTS devices in competitive power market
- gain knowledge about reactive power requirements
- make a choice in the plant location and optimal equipment selection.

REFERENCES

1. Maket Operations in Electric Power Systems (IEEE)- Mohammad Shahidehpour,Hatim Yamin, Zuyi Li ,A John Wiley & Sons, Inc., Publications 2002
2. Understanding electric utilities and de-regulation, LorrinPhilipson, H. Lee Willis, Marcel Dekker Pub., 1998.
3. Power system economics: designing markets for electricity Steven Stoft, John Wiley & Sons, 2002.
4. Operation of restructured power systems. Kankar Bhattacharya, Jaap E. Daadler, Math H.J. Boolen, Kluwer Academic Pub., 2001.
5. Restructured electrical power systems: operation, trading and volatility Mohammad Shahidehpour, Muwaffaq Alomoush, Marcel Dekker Pub., 2001.

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1. http://file258.casebooks.org/m77gn_power-generation-operation-and-control.pdf
2. www.debtbooks.org/doa8j_ebooks-power-station-engieering-and-economy.

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	
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CO2	3	-	-	-	2	3	2	2	3	-	2	1	-	1
CO3	3	-	-	-	2	3	2	2	3	-	2	1	-	1
CO4	3	-	-	-	2	3	2	2	3	-	2	1	-	1
CO5	3	-	-	-	2	3	2	2	3	-	2	1	-	1

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PPS16204 POWER SYSTEM TRANSIENTS AND SURGE PROTECTION 3 0 0 3

COURSE OBJECTIVES

- To discuss thevarious types of power system transients and its effect on power system.
- To explain the lightning surges and various conventional lightning protection schemes.
- To understand Bewley's Lattice diagrams and mathematical model for calculation of transients.
- To infer knowledge related to temporary over voltages and switching surges.
- To analyze the recent advancements in insulation co-ordination.

UNIT I INTRODUCTION 9

Review of various types of power system transients – Lightning surges, switching surges: Inductive energy transient and capacitive energy transient - effect of transients on power systems- Surge voltage and surge current specifications.

UNIT II LIGHTNING SURGES 9

Lightning overview - Lightning Surges-Electrification of thunderclouds – Simpson's theory of thunderclouds - Direct and Indirect Strokes -stroke to tower and midspan- mathematical model to represent lightning– tower footing resistance -Advanced Lightning protection technique.

UNIT III TRANSIENT CALCULATION 9

Computation of transients - transient response of systems with series and shunt lumped parameters and distributed lines-Traveling wave concepts - Telegraphic Equation, reflection and refraction of travelling waves.– Bewley's Lattice diagrams for various cases – Analysis in time and frequency domain – Eigen value approach – Z-transform.

UNIT IV SWITCHING SURGES 9

Switching Transients - the circuit closing transient - the recovery transient initiated by the removal of the short circuit — double frequency transients - Closing and reclosing of lines – load rejection – fault initiation – fault clearing – short line faults – Ferro Resonance – isolator switching surges – temporary over voltages – surges on an integrated systems.

UNIT V INSULATION CO ORDINATION 9

Principles of insulation co-ordination – over voltages and insulation coordination in MV and HV recent advancements in insulation co ordination – BIL, Design of EHV system – Insulation coordination as applied to transformer, substations – Examples.

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

- understand various types of power system transients and its effect on power system.
- solve mathematical model for calculation of transients.
- generalize lightning surges and various conventional lightning protection schemes.
- know the temporary over voltages and switching surges.
- relate the recent advancements in insulation co ordination and its basic concepts.

REFERENCES

1. Allan Greenwood, ―Electrical Transients in Power Systems‖, Willey Interscience, New York, 2001.
2. C.S.Indulkar, DP Kothari, –Power System Transients‖ – A Statistical approach, Prentice Hall 1996.
3. Subir Ray, ―Electrical Power Systems – Concepts, Theory and Practice‖, Prentice Hall of India, New Delhi, 2007.
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5. Chakrabarthy.A.,Soni.M.L., Gupta.P.V. andBhatnagar.U.S., ―A Text Book on Power System Engineering– ,DhanpatRai& CoNewDelhi, 2005.

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2. ewh.ieee.org/soc/pes/malaysia/images/Switching_Surges_handout.pdf
3. www.siemens.com/download?DLA15_1161

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	
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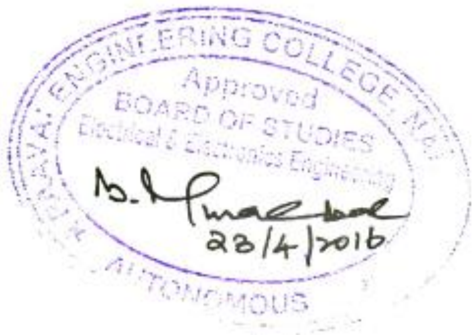
CO1	3	-	3	2	3	1	-	1	-	2	-	2	-	2
CO2	3	-	3	2	3	1	-	1	-	2	-	2	-	2
CO3	3	-	3	2	3	1	-	1	-	2	-	2	-	2
CO4	3	-	3	2	3	1	-	1	-	2	-	2	-	2
CO5	3	-	3	2	3	1	-	1	-	2	-	2	-	2



PPS16205 **POWER SYSTEM SIMULATION LABORATORY II** **0 0 4 2**

COURSE OBJECTIVES

- know stability analysis system
- study load flow and starting analysis
- study of STATCOM,PMSG, and DFIG for variable speed wind energy conversion system.
- understand relay coordination

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: 60 PERIODS

COURSE OUTCOMES

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

- Implement stability analysis system
- Demonstrate load flow and starting analysis
- design of STATCOM,PMSG, and DFIG for variable speed wind energy conversion system.
- Implement relay coordination

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	
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CO1	3	-	3	-	3	1	-	-	2	1	-	2	3	3
CO2	3	-	3	-	3	1	-	-	2	1	-	2	3	3
CO3	3	-	3	-	3	1	-	-	2	1	-	2	3	3
CO4	3	-	3	-	3	1	-	-	2	1	-	2	3	3

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PPS16206 **TECHNICAL SEMINAR II** **0 0 2 1**

COURSE OBJECTIVES

- To enhance the communication skills
- To improve presentational skills for betterment of their carrier.
- To enhance leadership quality.
- To Progress Employability.

In this course, every student has to present at least two technical papers on recent advancements in engineering/technology referring journal papers and will be evaluated by the course instructor. During the seminar session, each student is expected to present a topic, for duration of about 15 to 20 minutes which will be followed by a discussion for 5 minutes. Each student is responsible for selecting a suitable topic that has not been presented previously. Every student is expected to participate actively in the ensuing class discussion by asking questions and providing constructive criticism.

TOTAL: 30 PERIODS

COURSE OUTCOMES

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

- acquire knowledge in communication
- technical presentation skills
- expose leadership quality
- success in employment.

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	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	-	-	-	-	2	1	2	3	3	1	3	3	3
CO2	3	-	-	-	-	2	1	2	3	3	1	3	3	3
CO3	3	-	-	-	-	2	1	2	3	3	1	3	3	3
CO4	3	-	-	-	-	2	1	2	3	3	1	3	3	3

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ELECTIVE I

PPE16151 **ANALYSIS OF INVERTERS** **3 0 0 3**

COURSE OBJECTIVES

- To provide the electrical circuit concepts behind the different working modes of single phase inverters.
- To brief the different working modes of three-phase inverters and various switching techniques.
- To gain knowledge in the design and development of current source inverters.
- To analyze and comprehend the various operating modes of different configurations of power converters.
- To familiarize the concepts of various resonant inverter techniques and its application.

UNIT I SINGLE PHASE INVERTERS 12

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

UNIT II THREE PHASE VOLTAGE SOURCE INVERTERS 9

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

UNIT III CURRENT SOURCE INVERTERS 9

Operation of six-step thyristor inverter – inverter operation modes – load – commutated inverters – Autosequential current source inverter (ASCI) – current pulsations – comparison of current source inverter and voltage source inverters.

UNIT IV MULTILEVEL INVERTERS 9

Multilevel concept – diode clamped – flying capacitor – cascade type multilevel inverters - Comparison of multilevel inverters - application of multilevel inverters.

UNIT V RESONANT INVERTERS 6

Series and parallel resonant inverters - voltage control of resonant inverters – Class E resonant inverter – resonant DC – link inverters- advancements in inverter technology for industrial applications.

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

- understand the various circuit concepts of single phase inverters.
- analyse the working of three phase inverters with modulation techniques.
- design and develop current source inverters.
- derive the design criteria and analyse the various operating modes of different configurations of power converters.
- design inverters for various power applications.

REFERENCES

1. Rashid M.H., ―Power Electronics Circuits, Devices and Applications", Prentice Hall India, New Delhi, 2011.
2. Bimal K.Bose., ‗Modern Power Electronics and AC Drives‖, Pearson Education, 2009.

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2. https://myarchive4u.wordpress.com/.../power-electronics-circuitsdevices-.
3. 7see.blogspot.com/2015/06/power-electronics-by-ps-bimbra-free.html

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CO's	Programme Outcomes PO's												PSO's	
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CO4	3	3	3	-	-	1	-	1	-	2	-	2	1	3
CO5	3	3	3	-	-	1	-	1	-	2	-	2	1	3

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PPS16152 **POWER SYSTEM SECURITY** **3 0 0 3**

COURSE OBJECTIVES

- To infer knowledge in the security system.
- To understand the power system based various state estimation system.
- To discuss the security assessment in the different networks.
- To analyze the security enhancement methods.
- To explain the security in deregulated environment system.

UNIT I INTRODUCTION 9

Power system stability- security- observability and reliability, deregulation, factors affecting power system security, decomposition and multilevel approach, state estimation, system monitoring, security assessment, static and dynamic – online and offline, security enhancement.

UNIT II POWER SYSTEM STATE ESTIMATION 9

DC and AC network, orthogonal decomposition algorithm, detection identification of bad measurements, network observability and pseudo measurements, application of power system state estimation, introduction to supervisory control and data acquisition.

UNIT III SECURITY ASSESSMENT 9

Detection of network problems, network equivalent for external system, network sensitivity methods, calculation of network sensitivity factors, fast contingency algorithms, contingency ranking, dynamic security indices.

UNIT IV SECURITY ENHANCEMENT 9

Correcting the generator dispatch by sensitivity methods, compensated factors, security constrained optimization, preventive, emergency and restorative control through NLP and LP methods.

UNIT V SECURITY IN DEREGULATED ENVIRONMENT 9

Need and conditions for deregulation, electricity sector structure model, power wheeling transactions, congestion management methods, available transfer capability (ATC), system security in deregulation.

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

- summarize the fundamentals of security system.
- compare the estimation and measurements of power system.
- analyze and design the security assessment in network.
- understand the security assessment network problems.
- specify the recent techniques in security system.

REFERENCES

1. Wood, A.J. and Wollenberg, ―B.F., Power generation, Operation and Control‖, John Wiley and Sons, 2013.
2. Handsching.E, (Editor), ―Real time control of Electric Power Systems‖, Elsevier publishing Co., Amsterdam, 1972.

3. George Anders, Alfredo Vaccaro, ―Innovations in Power Systems Reliability‖, Springer publishing &Co,2011
4. K.Bhattacharya, M.H.J Bollen and J.E. Daaider, ―Operation of restructured power system‖ Kluwer Power Electronics and Power System series (2001)
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CO3	3	-	-	-	2	3	2	2	3	-	2	1	-	2
CO4	3	-	-	-	2	3	2	2	3	-	2	1	-	2
CO5	3	-	-	-	2	3	2	2	3	-	2	1	-	2

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PPS16153 LINEAR AND NON-LINEAR SYSTEM THEORY 3 0 0 3

COURSE OBJECTIVES

- To expose the state space design of linear and non-linear systems.
- To analyze nonlinear systems and determine their stability.
- To design the feedback controllers and observers for linear and nonlinear systems.

UNIT I STATE VARIABLE REPRESENTATION 9

Introduction-Concept of State equation for Dynamic Systems -Time invariance and linearity- Non uniqueness of state model-State Diagrams - Physical System and State Assignment.

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-Evaluation of matrix exponential.

UNIT III FEEDBACK CONTROLLERS AND OBSERVERS 9

Controllability and Observability-Test for Continuous time Systems- Time varying and Time invariant case-Output Controllability-Controllable and Observable Companion Forms-SISO and MIMO Systems-Pole Placement by State Feedback for both SISO and MIMO Systems-Full Order and Reduced Order Observers.

UNIT IV ANALYSIS OF NON LINEAR SYSTEMS 9

Classification of nonlinearity-physical nonlinearities-Linearization of nonlinear systems-phase plane analysis-describing function analysis of nonlinear systems-Application of describing functions.

UNIT V STABILTY 9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

- apply the mathematical fundamentals for deriving the state model.
- analyze the design of linear and nonlinear systems.
- determine whether the complex control systems are stable or not.

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3. K. Ogatta, –Modern Control Engineering‖, Pearson Education Asia, 2010.

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2. https://www.scribd.com/.../Control-Systems-Engineering-Nagrath-I-J-and...
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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	
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CO2	3	3	3	3	-	1	-	-	2	-	-	3	2	3
CO3	3	3	3	3	-	1	-	-	2	-	-	3	2	3
CO4	3	3	3	3	-	1	-	-	2	-	-	3	2	3
CO5	3	3	3	3	-	1	-	-	2	-	-	3	2	3

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ELECTIVE II

PPS16251 HIGH VOLTAGE DIRECT CURRENT TRANSMISSION 3 2 0 4

COURSE OBJECTIVES

- To discuss the basic concepts of HVDC with existing HVDC projects.
- To analyze the HVDC Converters and HVDC system control and harmonics and filtering.
- To gain knowledge about the types of multi terminal DC systems.
- To understand the concepts of power flow analysis in AC/DC systems.
- To explain the basic concepts of simulation of HVDC systems.

UNIT I DC POWER TRANSMISSION TECHNOLOGY 15

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

UNIT II ANALYSIS OF HVDC CONVERTERS AND HVDC SYSTEM CONTROL 15

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

UNIT III MULTITERMINAL DC SYSTEMS 15

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

UNIT IV POWER FLOW ANALYSIS IN AC/DC SYSTEMS 15

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

UNIT V SIMULATION OF HVDC SYSTEMS 15

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

TOTAL: 75 PERIODS

COURSE OUTCOMES

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

- understand the basic concept of DC power transmission technology.
- analyze HVDC converters and HVDC system control with converter.
- know the concepts of multi terminal DC systems with control and protection of MTDC system.
- analyze the solution of AC/DC power flow analysis.
- design the simulation of HVDC systems with Philosophy and tools.

REFERENCES

1. K.R.Padiyar, , ―HVDC Power Transmission Systems‖, New Age International (P) Ltd., New Delhi, 2010.
2. J.Arrillaga, , ‗High Voltage Direct Current Transmission‖, Peter Pregrinus, London,1983.

3. P. Kundur, ―Power System Stability and Control‖, McGraw-Hill, 2000.
4. ErichUhlmann, –Power Transmission by Direct Current‖, BS Publications, 2004.
5. V.K.Sood,HVDC and FACTS controllers – Applications of Static Converters in Power System,April 2004 , Kluwer Academic Publishers.
6. S.Kakshaish, V.Kamaraju, ―HVDC Transmission‖, TMH Publishers, 2012.

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3. www.sari-energy.org/...We...Power_Systems.../lecture_11.pdf

CO-PO MAPPING:

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CO's	Programme Outcomes PO's												PSO's	
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CO1	3	-	3	-	-	1	-	1	-	2	-	2	1	3
CO2	3	-	3	-	-	1	-	1	-	2	-	2	1	3
CO3	3	-	3	-	-	1	-	1	-	2	-	2	1	3
CO4	3	-	3	-	-	1	-	1	-	2	-	2	1	3
CO5	3	-	3	-	-	1	-	1	-	2	-	2	1	3

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PPS16252 POWER QUALITY ANALYSIS 3 2 0 4

COURSE OBJECTIVES

- To understand the concepts of the power quality Issues
- To explain the power and energy measurements, power factor measurements
- To infer knowledge in the single phase voltage sag
- To describe the power quality considerations in industries
- To discuss the mitigation of interruptions and voltage sags

UNIT I INTRODUCTION 15

Introduction of the Power Quality (PQ) problem, Terms used in PQ: Voltage, Sag, Swell, Surges, Harmonics, over voltages, spikes, Voltage fluctuations, Transients, Interruption, overview of power quality phenomenon, Remedies to improve power quality, power quality monitoring.

UNIT II LONG & SHORT INTERRUPTIONS 15

Interruptions – Definition – Difference between failures, outage, Interruptions – causes of Long Interruptions – Origin of Interruptions – Limits for the Interruption frequency – Limits for the interruption duration – costs of Interruption – Overview of Reliability evaluation to power quality, comparison of observations and reliability evaluation.

Short interruptions: definition, origin of short interruptions, basic principle, fuse saving, voltage magnitude events due to re-closing, voltage during the interruption, monitoring of short interruptions, difference between medium and low voltage systems. Multiple events, single phase tripping – voltage and current during fault period, voltage and current at post fault period, stochastic prediction of short interruptions.

UNIT III 1 & 3-PHASE VOLTAGE SAG CHARACTERIZATION 15

Voltage sag – definition, causes of voltage sag, voltage sag magnitude, and monitoring, theoretical calculation of voltage sag magnitude, voltage sag calculation in non-radial systems, meshed systems, and voltage sag duration. Three phase faults, phase angle jumps, magnitude and phase angle jumps for three phase unbalanced sags, load influence on voltage sags.

UNIT IV POWER QUALITY CONSIDERATIONS IN INDUSTRIAL POWER SYSTEMS 15

Voltage sag – equipment behavior of Power electronic loads, induction motors, synchronous motors, computers, consumer electronics, adjustable speed AC drives and its operation. Mitigation of AC Drives, adjustable speed DC drives and its operation, mitigation methods of DC drives.

UNIT V MITIGATION OF INTERRUPTIONS & VOLTAGE SAGS 15

Overview of mitigation methods – from fault to trip, reducing the number of faults, reducing the fault clearing time changing the power system, installing mitigation equipment, improving equipment immunity, different events and mitigation methods. System equipment interface – voltage source converter, series voltage controller, shunt controller, combined shunt and series controller.

TOTAL: 75 PERIODS

COURSE OUTCOMES

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

- discuss the various power quality issues.

- understand the concept of power and energy measurements, power factor measurements.
- know the concept of single and three phase voltage sag.
- gain knowledge in the power quality considerations in industrial power.
- use the concept of mitigation of interruptions and voltage sags.

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1. Math H J Bollen , ―Understanding Power Quality Problems‖, IEEE Press, 2000.
2. R. SastryVedam Mulukutla S. Sarma , ―Power Quality VAR Compensation in Power Systems‖, CRC Press, 2008.
3. C. Sankaran, –Power Quality‖, CRC Press, 2001.
4. Roger C. Dugan , Mark F. Mc Granaghan, H. Wayne Beaty, ―Electrical Power Systems Quality‖, Tata McGraw Hill , 2012

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2. read.pudn.com/downloads156/.../Power%20System%20Harmonics.pdf
3. accessengineeringlibrary.com/.../electrical-power-systems-quality-third-edition.

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	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	-	3	-	2	2	-	-	-	-	2	1	2	1
CO2	3	-	3	-	2	2	-	-	-	-	2	1	2	1
CO3	3	-	3	-	2	2	-	-	-	-	2	1	2	1
CO4	3	-	3	-	2	2	-	-	-	-	2	1	2	1
CO5	3	-	3	-	2	2	-	-	-	-	2	1	2	1

PPE16253 **ELECTRICAL GROUNDING** **3 2 0 4**

COURSE OBJECTIVES

- To understand the concept of grounding of power supply system.
- To infer knowledge on the equipment grounding.
- To elucidate the ground electrode system and soil resistance.
- To describe the electrical noise and mitigation. .
- To discuss the grounding practices on UPS systems.

UNIT I INTRODUCTION 15

Bonding - Lightning and its effect on electrical systems - Static charges and the need for bonding-Ground electrodes and factors affecting their efficacy - Noise in signaling circuits and protective measures: shielding-Surgeprotection of electronic equipment - UPS systems and their role in power quality improvement - ungrounded systems - Solidly grounded systems - Impedance grounding using neutral reactor - Resonant grounding using neutral reactor - Impedance grounding through neutral resistance Point of grounding.

UNIT II EQUIPMENT GROUNDING 15

Shock hazard Grounding of equipment-Operation of protective devices -Thermal capability -Touch Potential during ground faults- Induced voltage problem -Mitigation by multiple ground connection- Mitigation by reductionof conductor spacing-EMI suppression- Metal enclosures for grounding conductors- Grounding connections for surge protection equipment -Sensing of ground faults- Equipotential bond.

UNIT III GROUND ELECTRODE SYSTEM 15

Grounding electrodes-Soil resistance -Measurement of soil resistivity -Resistance of a single rod electrode - Current-carrying capacity of an electrode -Use of multiple ground rods in parallel -Measurement of ground resistance of an electrode-Concrete-encased electrodes -Corrosion problems in electrical grounding systems - Maintenance of grounding system -Chemical electrodes.

UNIT IV ELECTRICAL NOISE AND MITIGATION 15

Definition of electrical noise and measures for noise reduction -Frequency analysis of noise-Categories of noise-Disturbances from other equipment in the same distribution system -Earth loop as a cause of noise-The ways in which noise can enter a signal cable and its control -More about shielding -Shielded isolation transformer- Avoidance of earth loop-Use of insulated ground (IG) receptacle -Zero signal reference grid and signal-transport ground plane Harmonics in electrical systems.

UNIT V UPS SYSTEMS AND THEIR GROUNDING PRACTICES 15

Power quality issues-Definitions of abnormal voltage conditions-Susceptibility and measures to handle voltage abnormalities regulating transformer-Standby sources-Electromechanical UPS systems-Solid-state UPS systems - Multiple units for redundancy Considerations in selection of UPS systems for ADP facilities-Grounding issues in static UPS -configurations UPS configurations and recommended grounding practices.

TOTAL: 75 PERIODS

COURSE OUTCOMES

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

- understand the concept of grounding of power supply system.

- gain knowledge in the equipment grounding.
- explain the ground electrode system and soil resistance.
- analyse the electrical noise and mitigation. .
- enumerate the grounding practices on UPS systems.

REFERENCES

1. G Vijayaraghavan, Mark Brown, Malcolm Barnes Butterworth-Heinemann, –Practical Grounding, Bonding, Shielding and Surge Protection‖ Newnes is an imprint of Elsevier 2004.
2. Phil Simmons, ―Electrical Grounding and Bonding‖ Based on the 2011 NEC Codes 2014.
3. James G. Stallcup, James W. Stallcup,‖ Electrical Grounding and Bonding Simplified‖ Based on the NEC Codes and Standards 2002.

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2. https://www.progress-energy.com/assets/www/docs/business/Grounding.pdf
3. https://www.mikeholt.com/instructor2/img/product/pdf/1292432628sample.pdf

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	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	3	-	2	1	-	-	-	-	2	1	2	1
CO2	3	2	3	-	2	1	-	-	-	-	2	1	2	1
CO3	3	2	3	-	2	1	-	-	-	-	2	1	2	1
CO4	3	2	3	-	2	1	-	-	-	-	2	1	2	1
CO5	3	2	3	-	2	1	-	-	-	-	2	1	2	1

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ELECTIVE III

PPS16351 ENERGY AUDITING AND MANAGEMENT 3 0 0 3

COURSE OBJECTIVES

- To discuss and analyse the various energy security energy auditing
- To analyze the various method in energy auditing and economics
- To impact knowledge of the energy efficient in motors and transformers .
- To explain the various method of reactive power management and lighting
- To describe the auditing of cogeneration and conservation In Industries

UNIT I INTRODUCTION 9

Power system security, factors affecting power system security, contingency analysis, linear sensitivity factors, contingency selection, concentric relaxation, calculation of network sensitivity factors. Transmission planning criteria.

UNIT II ENERGY AUDITING AND ECONOMICS 9

System approach and End use approach to efficient use of Electricity; Electricity tariff types ;Energy auditing- Types and objectives-audit instruments –ECO assessment and Economic methods-cash flow model, time value of money, evaluation of proposals, pay-back method, average rate of return method, internal rate of return method, present value method, profitability index, life cycle costing approach, investment decision and uncertainty, consideration of income taxes, depreciation and inflation in investment analysis- specific energy analysis- Minimum energy paths-consumption models.

UNIT III ENERGY EFFICIENT MOTORS AND TRANSFORMERS 9

Electric motors-Energy efficient controls- Motor Efficiency and Load Analysis-Energy efficient/high efficient Motors Load Matching and selection of motors. Variable speed drives -Pumps and Fans- Efficient Controlstrategies-Optimal selection and sizing – Optimal operation and Storage. Transformer Loading /Efficiency analysis, Feeder /cable Loss evaluation.

UNIT IV REACTIVE POWER MANAGEMENT AND LIGHTING 9

Reactive Power management –Capacitor Sizing-Degree of Compensation-Capacitor losses-Location-Placement-Maintenance-Case study. Economics of power factor improvement. Peak Demand controls- Methodologies –Types of Industrial Loads-Optimal Load scheduling-Case study. Lightning-Energy efficient light sources-Energy Conservation in lighting schemes. Electronic Ballast-Power quality issues-Luminaries.

UNIT V COGENERATION AND CONSERVATION IN INDUSTRIES 9

Cogeneration-Types and Schemes-Optimal operation of cogeneration plants- Case study. Electric loads of Air conditioning and Refrigeration –Energy conservation measures-Cool storage- Types- Optimal operation-Casestudy .Electric water heating-Geysers-Solar Water Heaters-Power Consumption in Compressors, Energy conservation measures-Electrolytic Process-Computer Control-Software –EMS.

TOTAL: 45 PERIODS

COURSE OUTCOME

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

- understand various factor affecting power system security

- classify the various methods involved in energy auditing and economics
- obtain knowledge in the energy efficient motors and transformers
- know the various technologies for reactive power management and lighting.
- understand the various technologies to conserve energy in electrical systems.

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1. Giovanni Petrecca,Industrial Energy Management :Principles and Application,The Kluwer international series-207,(1999)
2. Anthony J.Pansini,Kenneth .D. Smalling ,Guide to Electric Load Management , Pennwell Pub;(1998)
3. Howard .E.Jordan.Energy – Efficient Electric Motors and Their Applications ,Pleneum Pub Corp.2ndedition(1994)
4. Turner, Wayne C, Energy Management /Handbook,Lilburn,The Fairmont Press,2001.
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3. www.em-ea.org

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

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CO4	3	2	2	-	2	3	2	2	3	-	2	1	1	1
CO5	3	2	2	-	2	3	2	2	3	-	2	1	1	1

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PPS16352 ARTIFICIAL INTELLIGENCE AND ITS APPLICATION 3 0 0 3

COURSE OBJECTIVES

- To describe the artificial intelligence networks.
- To discuss the fuzzy logic operations.
- To analyze the application of genetic algorithm.
- To knowledge on neural networks and its real-time performance.
- To understand the PSO and DE techniques

UNIT I INTRODUCTION TO NEURAL NETWORKS 9

Basics of ANN – Perceptron -Delta learning rule –Back Propagation Algorithm- Multilayer Feed forward network-Memory models-Bi-directional associative memory-Hopfield network. Application of Neural Networks to load forecasting, Contingency Analysis-VAR control, Economic Load Dispatch.

UNIT II INTRODUCTION TO FUZZY LOGIC 9

Crispness-Vagueness-Fuzziness-Uncertainty-Fuzzy set theory Fuzzy sets-Fuzzy set operations-fuzzy measures-fuzzy relations-fuzzy function. Structure of fuzzy logic controller-fuzzification models-data base-rule base- inference engine defuzzification module. Control Schemes.

UNIT III APPLICATIONS TO AI TECHNIQUES 9

Decision making Control through fuzzy set theory-Use of fuzzy set models of LP and its scheduling problems- Fuzzy logic based power stabilizer.

UNIT IV GENETIC ALGORITHM AND ITS APPLICATIONS 9

Introduction – Simple Genetic Algorithm – Reproduction,.Crossover, Mutation, Advanced Operators in Genetic Search – Applications to voltage Control and Stability Studies.

UNIT V PSO AND DE TECHNIQUES 9

Introduction – Review on PSO and DE –Restoration using ParticleSwarm Optimization and Differential Evolution techniques - Formulation, applications.

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

- understand the basics of design aspects of neural networks.
- know the fundamentals of fuzzy logic.
- use the Fundamentals of genetic algorithm and application
- differentiate the fuzzy logic, genetic algorithm and neural networks in power systems.
- understand the basics of PSO and DE.

REFERENCES

1. James.A.Freeman and B.M.Skapura ―Neural Networks, Algorithms Applications and Programming techniques‖- Addison Wesley, 2000.
2. GeorgeKlir and Tina Folger,.A., ―Fuzzy sets, Uncertainty and Information‖, Prentice Hall of India Pvt.Ltd., 2002 .

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2. www.journals.elsevier.com/engineering-applications-of-artificial-intellige.
3. www.softcomputing.net/aciis.pdf

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CO5	3	2	2	-	2	3	2	2	3	-	2	1	3	3

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