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.
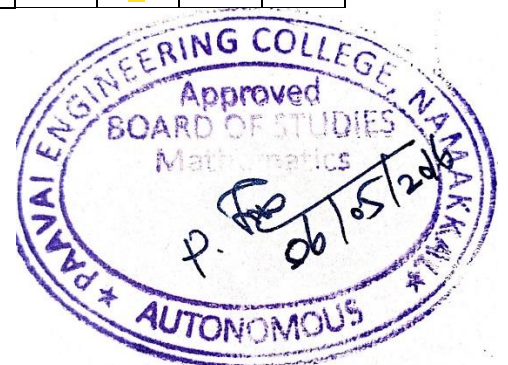
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4. Taha, H.A., ―Operations Research, An introduction‖, 10th edition, Pearson education, New Delhi, 2010.
5. Andrews L.C. and Phillips R.L., ―Mathematical Techniques for Engineers and Scientists‖, Prentice Hall of India Pvt.Ltd., New Delhi, 2005.
6. 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

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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

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.

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2. dl.lib.mrt.ac.lk/bitstream/handle/123/1748/92960_Post-text.pdf.

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

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.

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

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.

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

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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.

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3. C.L.Wadhwa, ―Electrical Power Systems‖, New Age International (P) Ltd Publishers, 2015.

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5. Arrillaga.J ―High Voltage Direct Current Transmission‖ 2nd Edition (London) peter Peregrines, IEEE, 1998.

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

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

CO-PO MAPPING:														
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CO4	3	-	3	-	3	1	-	-	2	1	-	2	3	3

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

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).

2. Hingorani, N.G. and Gyragyi, L., Understanding FACTS (Concepts and Technology of Flexible AC Transmission System), Standard Publishers & Distributors (2001).

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3. new.abb.com › Offerings › FACTS

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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

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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1. www.unge.gq/ftp/biblioteca%20digital/.../Estabilidad%20-%20kundur.p
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

CO's	Programme Outcomes PO's												PSO's	
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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

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.

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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

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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

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.

4. Rakosh das Begamudre, ‒Extra High Voltage AC Transmission Engineering‖, Wiley Eastern Ltd, New Delhi, 1990

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

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
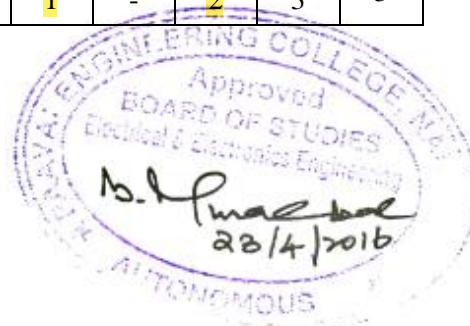
LIST OF EXPERIMENTS

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	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
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

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	
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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

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.

3. Ned Mohan, Undeland and Robbin, ―Power Electronics: converters, Application and design‖ John Wiley and sons. Inc, Newyork, 2009.

4. P.C. Sen, ‒Modern Power Electronics‖, S. Chand Limited, New Delhi, 2008.

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2. https://myarchive4u.wordpress.com/.../power-electronics-circuitsdevices-.

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CO-PO MAPPING:													
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CO4	3	3	3	-	-	1	-	1	-	2	-	2	1	3
CO5	3	3	3	-	-	1	-	1	-	2	-	2	1	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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WEB LINKS

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CO-PO MAPPING:

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

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.

REFERENCES

1. M.Gopal, ―Modern Control System theory‖, New Age International Publishers, 2014.
2. Nagrath I.J., and Gopal, M., ―Control Systems Engineering‖ New Age International Limited, 2013.
3. K. Ogatta, ‒Modern Control Engineering‖, Pearson Education Asia, 2010.

WEB LINKS

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3. een.iust.ac.ir/.../Linear%20Control%20System/Ogata%20Modern_Control_...

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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

<div align="center">**ELECTIVE II**</div>

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.

<div align="right">**TOTAL: 75 PERIODS**</div>

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.

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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.

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

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.

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	Programme Outcomes PO's												**PSO's**	
CO's	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
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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:

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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

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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2. www.nptel.ac.in/syllabus/108106022/

3. www.em-ea.org

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

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.

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

ELECTIVE IV

PPS16451   **DEREGULATION OF POWER SYSTEMS**   **3   0   0   3**

COURSE OBJECTIVES

- To discuss the restructuring of power industry and market models based on Contractual arrangements
- To infer knowledge on fundamental concepts of congestion management.
- To analyse the concepts of locational marginal pricing and financial transmission rights.
- To understand marginal transmission pricing paradigm and pricing of transmission network.
- To explain the availability based tariff and framework of Indian power sector.

UNIT I   INTRODUCTION TO RESTRUCTURING OF POWER INDUSTRY   9

Introduction: Deregulation of power industry, Restructuring process, Issues involved in deregulation, Deregulation of various power systems – Fundamentals of Economics: Consumer behavior, Supplier behavior, Market equilibrium, Short and long run costs, Various costs of production – Market models: Market models based on Contractual arrangements, Comparison of various market models, Electricity vis – a – vis other commodities, Market architecture, Case study.

UNIT II   TRANSMISSION CONGESTION MANAGEMENT   9

Introduction: Definition of Congestion, reasons for transfer capability limitation, Importance of congestion management, Features of congestion management – Classification of congestion management methods – Calculation of ATC - Non – market methods – Market methods – Nodal pricing – Inter zonal and Intra zonal congestion management – Price area congestion management – Capacity alleviation method.

UNIT III   LOCATIONAL MARGINAL PRICES AND FINANCIAL TRANSMISSION RIGHTS   9

Mathematical preliminaries: -Locational marginal pricing– Lossless DCOPF model for LMP calculation – Loss compensated DCOPF model for LMP calculation – ACOPF model for LMP calculation – Financial Transmission rights – Risk hedging functionality - Simultaneous feasibility test and revenue adequacy – FTR issuance process: FTR auction, FTR allocation – Treatment of revenue shortfall – Secondary trading of FTRs – Flow gate rights – FTR and market power - FTR and merchant transmission investment.

UNIT IV   ANCILLARY SERVICE MANAGEMENT AND PRICING OF TRANSMISSION   9
**   NETWORK**

Introduction of ancillary services – Types of Ancillary services – Classification of Ancillary services – Load generation balancing related services – Voltage control and reactive power support devices – Black start capability service - ancillary service –Co-optimization of energy and reserve services - International comparison - Transmission pricing – Principles – Classification – Role in transmission pricing methods – Marginal transmission pricing paradigm – Composite pricing paradigm – Merits and demerits of different paradigm.

UNIT V   REFORMS IN INDIAN POWER SECTOR   15

Introduction – Framework of Indian power sector – Reform initiatives - Availability based tariff – Electricity act 2003 – Open access issues – Power exchange – Reforms in the near future.

TOTAL PERIODS   45

COURSE OUTCOMES

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

- understand the restructuring of power industry and market models based on Contractual arrangements.
- use the knowledge on fundamental concepts of congestion management.
- analyze the operation of central processing and arithmetic logic units.
- demonstrate the availability based tariff.
- framing of Indian power sector.

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1. Mohammad Shahidehpour, MuwaffaqAlomoush, Marcel Dekker, "Restructured electrical power systems: operation, trading and volatility" Pub., 2001.
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2. www.powershow.com/.../Deregulation_as_a_Power_Engineering_Course.
3. www.powerworld.com/files/tjo_sum99_market.ppt

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

PPS16452   **DISTRIBUTED GENERATION AND MICROGRID**   **3 0 0 3**

COURSE OBJECTIVES

- To understand Conventional power generation
- To analyze interconnecting distributed resources to electric power systems.
- To point out the impact of grid integration with NCE sources on existing power system.
- To study concept and definitions of Micro grid and its configuration.
- To produce knowledge on various power quality issues in micro grids.

UNIT I INTRODUCTION   **9**

Conventional power generation: Advantages and disadvantages, Energy crises, Non-Conventional Energy (NCE) resources: Review of Solar PV, Wind Energy systems, Fuel Cells, Micro-turbines, Biomass, and Tidal sources.

UNIT II DISTRIBUTED GENERATIONS (DG)   **9**

Concept of distributed generations, topologies, selection of sources, regulatory standards/ framework, Standards for interconnecting Distributed resources to electric power systems: IEEE 1547.DG installation classes, security issues in DG implementations. Energy storage elements: Batteries, ultra-capacitors, flywheels. Captive power plants

UNIT III GRID INTEGRATION IN DG   **9**

Requirements for grid interconnection, limits on operational parameters: Voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues. Impact of grid integration with NCE sources on existing power system: reliability, stability and power quality issues

UNIT IV MICROGRIDS   **10**

Concept and definition of microgrid, microgrid drivers and benefits, review of sources of microgrids, typical structure and configuration of a microgrid, AC and DC microgrids, Power Electronics interfaces in DC and AC microgrids, communication infrastructure, modes of operation and control of microgrid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes.

UNIT V POWER QUALITY ISSUES IN MICROGRIDS   **8**

Power quality issues in micro grids- Modeling and Stability analysis of Microgrid, regulatory standards, Microgrid economics, Introduction to smart micro grids

                                        TOTAL PERIODS   45

COURSE OUTCOMES

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

- apply the basic concept of distributed generation.
- summarize the interconnecting Distributed resources to electric power systems.
- analyze the impact of grid integration with NCE sources on existing power system.
- study the concepts and definitions of Microgrid and its configuration.
- demonstrate the availability based tariff and framework of Indian power sector.
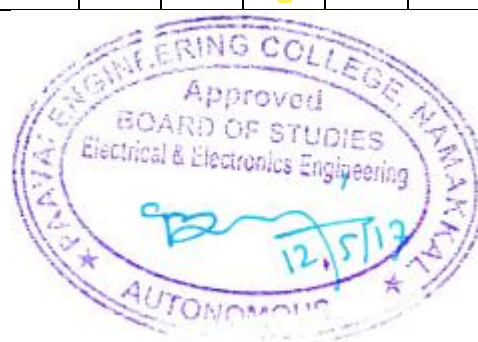
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CO4	3	2	3	-	2	1	-	-	-	-	2	1	3	3
CO5	3	2	3	-	2	1	-	-	-	-	2	1	3	3

PPS16453   **INDUSTRIAL POWER SYSTEM ANALYSIS AND DESIGN**   **3 0 0 3**

COURSE OBJECTIVES

- To study about motor starting methods
- To analyze the harmonic sources.
- To design the harmonic filters.
- To understand the flicker analysis and case study.
- To know about ground grid analysis.

UNIT I   MOTOR STARTING STUDIES   9

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

UNIT II   POWER FACTOR CORRECTION STUDIES   9

Introduction-System Description and Modeling-Acceptance Criteria-Frequency Scan Analysis-Voltage Magnification Analysis-Sustained Overvoltage"s-Switching Surge Analysis-Back-to-Back Switching-Summary and Conclusions

UNIT III   HARMONIC ANALYSIS   9

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

UNIT IV   FLICKER ANALYSIS   9

Sources of Flicker-Flicker Analysis-Flicker Criteria-Data for Flicker analysis- Case Study- Arc Furnace Load-Minimizing the Flicker Effects-Summary.

UNIT V   GROUND GRID ANALYSIS   9

Introduction-Acceptance Criteria-Ground Grid Calculations-Computer-Aided Analysis - Improving the Performance of the Grounding Grids-Conclusions.

                                                          TOTAL PERIODS   45

COURSE OUTCOMES

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

- demonstrate the motor starting techniques.
- demonstrate the power factor correction techniques
- determine the level of harmonics and its effect.
- analysis the flickers and methods of minimizing its effects.
- explain about ground grid analysis

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1. Ramasamy Natarajan, "Computer-Aided Power System Analysis", Marcel DekkerInc., 2002.
2. J. Duncan Glover, MulukutlaS.Sarma, Thomas Overbye, "Power System Analysis and Design", 2011.
3. Patrick H Garrett," High performance Instrumentation and Automation", CRC Press, Taylor & Francis Group, 2005.

4. TuranGonen "Electrical Power Transmission System Engineering: Analysis and Design", Mcgraw Hill publishers,2008.

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

PPS16551   **ADVANCED POWER SYSTEM DYNAMICS**   3   0   0   3

COURSE OBJECTIVES

- To apply transient stability analysis using unified algorithm.
- To describe knowledge on sub-synchronous resonance and oscillations.
- To analyze the mathematical model of the synchronous machine to analyze it under stationary and transient conditions.
- To describe the transient stability problems and to protect the system against stability problems.
- To infer knowledge on voltage stability problems by applying transient stability enhancement methods.

UNIT I   TRANSIENT STABILITY ANALYSIS   9

Review of numerical integration methods: Euler and Fourth Order Runge-Kutta methods, Numerical stability and implicit methods, Simulation of Power System Dynamic response: Structure of Power system Model, Synchronous machine representation: equations of motion, rotor circuit equations, stator voltage equations, Thevenin's and Norton's equivalent circuits, Excitation system representation, Transmission network and load representation, Overall system equations and their solution

UNIT II   SUBSYNCHRONOUS OSCILLATIONS   9

Introduction – Turbine Generator Torsional Characteristics: Shaft system model – Examples of torsional characteristics – Torsional Interaction with Power System Controls: Interaction with generator excitation controls – Interaction with speed governors – Interaction with nearby DC converters.

UNIT III   SUBSYNCHRONOUS RESONANCE (SSR)   9

Sub synchronous Resonance (SSR): Characteristics of series –Compensated transmission systems – Self-excitation due to induction generator effect – Torsional interaction resulting in SSR – Analytical Methods – Numerical examples illustrating instability of sub synchronous oscillations – Impact of Network-Switching Disturbances: Steady-state switching – Successive network-Switching disturbances – time-domain simulation of sub synchronous resonance – EMTP with detailed synchronous machine model.

UNIT IV   TRANSMISSION, GENERATION AND LOAD ASPECTS OF VOLTAGESTABILITY   9
**   ANALYSIS**

Review of transmission aspects – Generation Aspects: Review of synchronous machine theory – Voltage and frequency controllers – Limiting devices affecting voltage stability – Voltage-reactive power characteristics of synchronous generators – Capability curves – Effect of machine limitation on deliverable power – Load Aspects – Voltage dependence of loads – Load restoration dynamics – Induction motors – Load tap changers – Thermo static load recovery – General aggregate load models.

UNIT V   ENHANCEMENT OF TRANSIENT STABILITY AND COUNTER MEASURES FOR   9
**   SUB SYNCHRONOUS RESONANCE**

Principle behind transient stability enhancement methods: high-speed fault clearing, reduction of transmission system reactance, regulated shunt compensation, dynamic braking, reactor switching, independent pole-operation of circuit-breakers, single-pole switching, fast-valving, high-speed excitation systems; NGH damper scheme.

TOTAL PERIODS   45

COURSE OUTCOMES

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

- apply numerical integration methods to analyze transient stability.
- understand Torsional Interaction with Power System Controls
- solve Switching Disturbances in Sub synchronous resonance
- analyze voltage stability in Transmission, generation and load aspects
- understand and apply various transient stability enhancement methods

REFERENCES

1. P. Kundur, Power System Stability and Control, McGraw-Hill, 1993.
2. Narendra and Annasamy," Stable Adaptive Control Systems, Prentice Hall, 1989.
3. H. W. Dommel, EMTP THEORY BOOK, Microtran Power System Analysis Corporation, Second Edition, 1996.

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2. www.nptelvideos.in/2012/11/power-system-dynamics.
3. www.cdeep.iitb.ac.in/NPTEL2/video_courses

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

PPS16552   **SMART GRID DESIGN AND ANALYSIS**   **3 0 0 3**

COURSE OBJECTIVES

- To produce a comprehensive understanding on design and analysis of smart grids
- To understand the phasor measurement unit technologies in smart grid.
- To understand the wide area measurement system in smart grid.
- To apply advanced analytic tools in planning and operation of smart grids.
- To discuss the renewable energy resources and storages integrated with smart grid

UNIT I   SMART GRID ARCHITECTURAL DESIGNS   9

Introduction – Comparison between existing grid and smart grid– power system enhancement – communication and standards - General View of the Smart Grid Market Drivers - Stakeholder Roles and Function - Measures - Representative Architecture - Functions of Smart Grid Components Wholesale energy market in smart grid

UNIT II   PHASOR MEASUREMENT UNIT TECHNOLOGY   8

Architecture, Functions, Optimal Placement of PMUs, Phasor data concentrators and associated communication system. Visualization tools to enhance visibility and control within transmission system, PMU measurements and sampling rates State Estimation & observability by using PMU, phasor data use for real time operation, frequency stability monitoring and trending, power oscillation, voltage monitoring and trending. Alarming and setting system operating limits. Dynamic line rating and congestion management, outage restoration. Application of PMU for wide area monitoring and control.

UNIT III   WIDE AREAMEASUREMENT SYSTEM   9

Architecture, Components of WAMS, GUI (Graphical User Interface), Applications: Voltage Stability Assessment, Frequency stability Assessment, Power Oscillation Assessment, Communication needs of WAMS, WAMPAC (Wide Area Monitoring Protection & Control), RAS (Remedial Action Scheme). Standards: IEEE 1344, IEEEC37.118 (2005), IEEE Standard C37.111-1999 (COMTRADE), IEC61850 GOOSE.

UNIT IV   STABILITY ANALYSIS TOOLS FOR SMART GRID   10

Voltage Stability Analysis Tools-Voltage Stability Assessment Techniques-Voltage Stability Indexing- Application and Implementation Plan of Voltage Stability in smart grid- Pathway for designing smart grid- Approach of smart grid to State Estimation-Energy management in smart grid. Environmental impacts.

UNIT V   SUSTAINABLE ENERGY AND GRID INTEGRATION   9

Sustainable Energy Options for the Smart Grid-Penetration and Variability Issues Associated with Sustainable Energy Technology-Demand Response Issues-Electric Vehicles and Plug-in Hybrids PHEV Technology-Environmental Implications-Storage Technologies-Grid integration issues of renewable energy sources.

TOTAL PERIODS   45

COURSE OUTCOMES

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

- summarize the understanding on recent development of power grids.
- apply advanced analysis tools in planning and operation of smart grids
- analyze the stability of smart grid.
- demonstrate the renewable energy resources and storages integrated with smart grid.

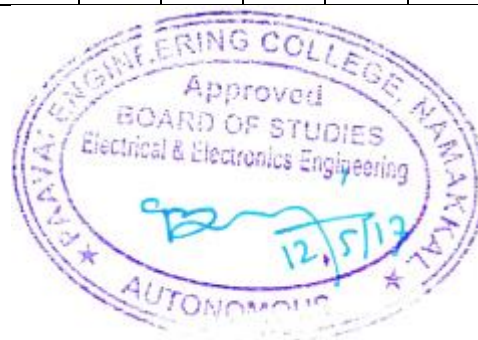- integrate the sustainable energy and grid integration.

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1. James Momoh, "Smart Grid: Fundamentals of design and analysis", John Wiley & sons Inc, IEEE press 2012.

2. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", John Wiley & sons inc, 2012.

3. Fereidoon P. Sioshansi, "Smart Grid: Integrating Renewable, Distributed & Efficient Energy", Academic Press, 2012.

4. Clark W.Gellings, "The smart grid: Enabling energy efficiency and demand response", Fairmont Press Inc, 2009.

5. "Smart Grid Infrastructure & Networking", Krzysztof Iniewski, Tata McGraw-HillEdition. 2012

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2. www.iitk.ac.in/...2%20IITK/Smart%20Grid%20Concept%20&%20Deplo
3. nptel.ac.in/courses/102103044/pdf/mod6.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

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

PPS16553   **COMPUTER AIDED POWER SYSTEMS ANALYSIS**   **3 0 0 3**

COURSE OBJECTIVES

- To know power flow analysis using matrix method.
- To learn the basic concepts to analyze the faults in power system.
- To understanding the stability analysis in power system.
- To design the matrix for port networks and power flow problems.
- To study the computer aided power flow analysis.

UNIT I INTRODUCTION TO AC POWER FLOW ANALYSIS   **9**

Introduction, Review of Fundamentals, Types of power system analysis, Modeling of power system components, Basic Matrix Algebra, Formation of Y_{bus} Matrix, Power Flow Solution Algorithms, Newton Raphson Load Flow Method, AC-DC System Power Flow Analysis- Sequential and Simultaneous Solution Algorithms.

UNIT II FAULT ANALYSIS IN POWER SYSTEM   **9**

Analysis of Symmetrical and Unsymmetrical Faults, Shunt Faults, Series Faults, Formation of Z_{bus} Matrix Short Circuit Analysis of Large Power Systems using Z_{bus}, Analysis of Open Circuit faults.

UNIT III STABILITY ANALYSIS IN POWER SYSTEM   **9**

Basic Concepts of Voltage Stability Analysis, Small Signal Stability Analysis using Classical Model, Transient Stability Analysis of Multi-Machine Systems, Eigen Analysis of Dynamical Systems, Application of FACTS in Power system stability.

UNIT IV ANALYSIS OF SIMULTANEOUS FAULTS   **9**

Simultaneous faults, Simultaneous faults by Two – Port Network Theory (Z, Y and H Type Faults), Simultaneous faults by Matrix Transformation, Analytical Simplifications of Series and Shunt Faults.

UNIT V COMPUTER AIDED POWERFLOW ANALYSIS   **9**

Computer solution to Power flow problems, Solution using Admittance and Impedance Matrix, Comparison of Admittance and Impedance Matrix Techniques, Power-Flow problem, Power flow studies in System Design and Operation, Decoupled Power Flow Method.

                                                            TOTAL PERIODS   45

COURSE OUTCOMES

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

- apply the mathematical fundamentals for power flow analysis.
- determine the fault analysis.
- explain the stability analysis in power system.
- analyse and design the Port networks and Matrix transformation.
- determine a computer based solution for power flow problems.

REFERENCES

1. J.J. Grainger and W.D. Stevenson, " Power System Analysis", McGraw Hill, New York,1994.
2. G.L. Kusic, "Computer Aided Power Systems Analysis", Prentice Hall, 1986.
3. I.J. Nagrath and D.P. Kothari, "Modern Power System Analysis", Tata McGraw Hill, 1980.
4. P. Kundur, Power System Stability and Control, McGraw Hill, 1994.

5. J.D. Glover, M. Sarma and T.J. Overbye, Power System Analysis and Design, Fourth Edition, Thomson Engineering Press, 2008.

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2. https://www.scribd.com/.../Computer-Aided-Power-Systems-Analysis.

3. http://nptel.ac.in/courses/108107028/5

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

<center>**ELECTIVE VI**</center>

PPS16651   **APPLICATIONS OF MEMS TECHNOLOGY**   3   0   0   3

COURSE OBJECTIVES

- To design the concepts of new fabrication methods and more reliable MEMS technology.
- To understand the differentiate MEMS sensors and actuator based on electrostatic and thermal principles.
- To infer knowledge on the design of new MEMS device based on various principles.
- To study the design of MEMS devices that works based on various principles.
- To discuss the industrial application of MEMS device.

UNIT I   MEMS: MICRO-FABRICATION, MATERIALS AND ELECTROMECHANICALLY   9
**   CONCEPTS**

Overview of micro fabrication – Silicon and other material based fabrication processes – Concepts: Conductivity of semiconductors-Crystal planes and orientation-stress and strain-flexural beam bending analysis-torsional deflections-Intrinsic stress- resonant frequency and quality factor.

UNIT II   ELECTROSTATIC SENSORS AND ACTUATION   9

Principle, material, design and fabrication of parallel plate capacitors as electrostatic sensors and comb drive - micro motors-actuators-Applications.

UNIT III   THERMAL SENSING AND ACTUATION   9

Principle, material, design and fabrication of thermal couples, thermal bimorph sensors, thermal resistor sensors-Applications.

UNIT IV   PIEZOELECTRIC SENSING AND ACTUATION   9

Piezoelectric effect-cantilever piezo electric actuator model-properties of piezoelectric materials-Applications

UNIT V   CASE STUDIES   9

Piezoresistive sensors, Acceleration sensors, Magnetic actuation, Micro fluidics applications, Medical applications, Optical MEMS.-NEMS Devices Note :Discussions/Exercise/Practice on Workbench : on the basics /device model design aspects of thermal/peizo/resistive sensors etc

TOTAL PERIODS   45

COURSE OUTCOMES

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

- demonstrate the MEMS technology and MEMS materials.
- explain the different fabrication methods used in MEMS technology and packaging and reliability issues.
- classify the MEMS sensors and actuators working based on electrostatic principles.
- discuss the suitable applications of MEMS sensors and actuators working based on thermal principles.
- design MEMS devices that works based on various principles.

REFERENCES

1. Chang Liu, "Foundations of MEMS", Pearson International Edition, 2006.
2. Marc Madou , "Fundamentals of microfabrication",CRC Press, 1997.
3. Boston , "Micromachined Transducers Sourcebook",WCB McGraw Hill, 1998.

4. M.H.Bao "Micromechanical transducers: Pressure sensors, accelerometers and gyroscopes", Elsevier, Newyork, 2000.

5. Tai-Ran Hsu, "MEMS and Microsystems Design and Manufacture", Tata McGraw Hill, 2002.

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2. www.engr.uvic.ca/~mech466/MECH466-Lecture-8.pdf

3. www.engr.uvic.ca/~mech466/MECH466-Lecture-6.pdf

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

PPE16652   **VLSI DESIGN TECHNIQUES**   **3   0   0   3**

COURSE OBJECTIVES

- To describe the significance of CMOS technology and fabrication process.
- To understand the importance and architectural features of programmable logic devices.
- To apply the ASIC construction, design algorithms and basic analog VLSI design techniques.
- To explain the concepts of sequential system and floor planning.
- To study the logic synthesis and simulation of digital system using VHDL and Verilog HDL.

UNIT I   CMOS DESIGN   **9**

Overview of digital VLSI design Methodologies- Logic design with CMOS-transmission gate circuits - Pass Transistor - Clocked CMOS-dynamic CMOS circuits, Bi-CMOS circuits- Layout diagram, Stick diagram-IC fabrications – Trends in IC technology.

UNIT II   PROGRAMABLE LOGIC DEVICES   **12**

Programming Techniques-Anti fuse-SRAM-EPROM and EEPROM technology – Re- Programmable Devices Architecture- Function blocks, I/O blocks, Interconnects, Xilinx- XC9500,Cool Runner - XC-4000,XC5200, SPARTAN, Virtex - Altera MAX 7000-Flex 10KStratix.

UNIT III   BASIC CONSTRUCTION, PLACEMENT AND ROUTING   **6**

System partitioning– FPGA partitioning – Partitioning methods – placement physical design flow – global routing – detailed routing – special routing- circuit extraction –DRC.

UNIT IV   SEQUENTIAL SYSTEMS AND FLOOR PLANNING   **6**

Memory cells and Arrays, Clocking disciplines, Design, Power optimization, Design validation and testing.Floorplanning methods, Global Interconnect, Floor Plan Design, Off-chip connections.

UNIT V   LOGIC SYNTHESIS AND SIMULATION   **12**

Overview of digital design with Verilog HDL- hierarchical modeling concepts- modules and port definitions- gate level modeling- data flow modeling- behavioral modeling- task & functions- Verilog and logic synthesis-simulation-Design examples- Ripple carry Adders- Carry Look ahead adders- Multiplier- ALU- Shift Registers, Multiplexer- Comparator- Test Bench.

                                      TOTAL PERIODS 45

COURSE OUTCOMES

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

- understand the basic concepts of CMOS circuits.
- acquire knowledge on architectural features of programmable logic devices.
- understand basic analog VLSI design techniques.
- apply and use the sequential system circuits.
- design and simulate the basic analog and digital circuits using Verilog HDL.

REFERENCES

1. E. Eshranghian, D.A. Pucknell and S. Eshraghian, "Essentials of VLSI circuits and systems", PHI, 2010.
2. Neil H.E. Weste, David Harris and Ayan Banerjee, "CMOS VLSI Design, A circuits and Systems Perspective", 2010.

3. W. Wolf, "Modern VLSI Design", Fourth Edition, Pearson, 2009.

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2. etidweb.tamu.edu/.../VHDL%20Programming%20By%20Example%20d.

3. www.csit-sun.pub.ro/courses/vlsi/Modern_VLSI_Design.pdf.

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

PPE16653   **VIRTUAL INSTRUMENTATION SYSTEMS**   **3 0 0 3**

COURSE OBJECTIVES

- To infer knowledge on Virtual instrumentation Architecture.
- To analyze the new concepts on Graphical programming.
- To understand the programming structure for various parameters.
- To discuss the data acquisition and instrument control.
- To use the applications of hardware and software specifications.

UNIT I INTRODUCTION   **9**

General Functional description of a digital instrument - Block diagram and Architecture of a Virtual Instrument - Physical quantities and Analog interfaces - Hardware and Software – User interfaces - Advantages of Virtual instruments over conventional instruments –Data flow techniques - Architecture of a Virtual instrument and its relation to the operating system.

UNIT II INSTRUMENT INTERFACE   **9**

Interfacing of external instruments to a PC – RS 232, RS 422, RS 485 and USB Standards – IEEE 488 standard – ISO – OSI model for series bus – Introduction to bus protocols – Interface basis: USB, PCMCIA, VXI, SCXI, PXI etc.

UNIT III PROGRAMMING TECHNIQUE   **9**

FOR loops, WHILE loop, CASE structure, formula node, Sequence structures – Arrays and Clusters - Array operations - Bundle - Bundle/Unbundle by name, graphs and charts - String and file I/O - High level and Low level file I/O's.

UNIT IV DATA ACQUISTION   **9**

Installing hardware, installing drivers - Configuring the hardware –Introduction to data acquisition on PC, Sampling fundamentals,Input/Output techniques and buses. ADC, DAC, Digital I/O, counters and timers, DMA,Software and hardware installation, Calibration, Resolution, Data acquisition interface requirements.

UNIT V APPLICATIONS   **9**

Motion Control: General Applications - Feedback devices, Motor Drives – Machine vision – Instrument Connectivity - GPIB, Serial Communication - General, GPIB Hardware & Software specifications –Real –Time Systems, Embedded controller, OPC, HMI, SCADA software – Development of process database management system.

                                                            TOTAL PERIODS   45

COURSE OUTCOMES

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

- discuss the knowledge on Virtual instrumentation Architecture.
- apply the new concepts in Graphical programming.
- understand the programming structure for various parameters.
- summarize the data acquisition and instrument control.
- implement the applications of hardware and software specifications

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1. Lisa K. wells & Jeffrey Travis, LabVIEW for everyone, Prentice Hall, New Jersey,1997.

2. Gary Johnson, LabVIEW Graphical Programming, Second edition, McGraw Hill, Newyork, 1997.

3. Kevin James, PC Interfacing and Data Acquisition: Techniques for Measurement, Instrumentation and Control, Newnes, 2000.

4. N.Mathivanan, PC-based Instrumentation: Concepts and Practice, Eastern Economy Edition, PHILearning private Ltd,2007.

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