

SEMESTER I

PPS19101

ADVANCED POWER SYSTEM ANALYSIS

3 1 0 4

COURSE OBJECTIVES

To enable the students to

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

UNIT I SOLUTION TECHNIQUES

12

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

12

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

12

Problem statement - Solution of optimal power flow (OPF) – The gradient method, Newton's method, linear sensitivity analysis; LP methods with real power variables only – LP method with AC power flow variables and detailed cost functions - security constrained optimal power flow - Interior point algorithm - Bus Incremental costs.

UNIT IV SHORT CIRCUIT ANALYSIS

12

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 using Thevenin's equivalent and ZBUS matrix for different faults.

UNIT V TRANSIENT STABILITY ANALYSIS

12

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 PERIODS

60

COURSE OUTCOMES

At the end this course, students will be able to

- design proper mathematical models for analysis of power system components.
- illustrate 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.
- perform numerical integration to analyze power system transient stability.

REFERENCES

1. Grainger, J.D., "Power System Analysis", Tata McGraw Hill Publishing Company, 2016.
2. Kusic, C.L., "Computer Aided Power System Analysis", Tata McGraw Hill Publishing Company, Reprint 2017.
3. Pai, M. A., "Computer Techniques in Power System Analysis", TMH Publishing Company, Reprint 2015.
4. Stagg, G. W. and Elabadi, A. H., "Computer Methods in Power System Analysis", McGraw Hill, Reprint 2016.
5. Wood, A.J. and Wollenberg, B.F., "Power Generation, Operation and Control", John Wiley and Sons, 2015.
6. Singh L.P., "Advanced power system analysis and dynamics", 3rd Ed., Wiley eastern, New Delhi, 2015.

CO-PO MAPPING:

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

COURSE OBJECTIVES

To enable the students to

- know the basics of mathematical description of a synchronous machine.
- acquire knowledge in speed governing systems.
- understand the concepts of system stability analysis with and without controllers.
- deduce the stability and instability analysis of various power system networks.
- 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 with amortisseur windings 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, generic 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 infinitiesbus (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 in a 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 PERIODS 45

COURSE OUTCOMES

At the end this course, students will be able to

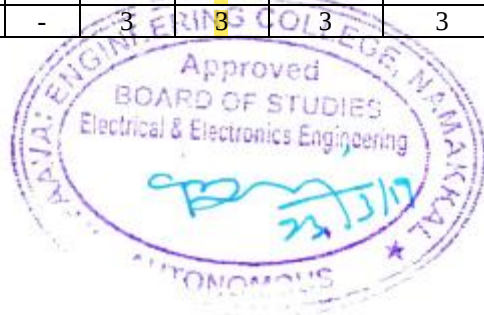
- describe the fundamental dynamic behavior of power systems.
- control the power systems to perform basic stability analysis.
- summarize the concepts in modeling and simulating the dynamic phenomena of power systems.
- interpret results of system stability studies. .
- demonstrate theory and practice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

REFERENCES

1. P. S. Kundur, “Power System Stability and Control”, McGraw-Hill, 2014.
2. K.R.Padiyar, “Power System Dynamics Stability & Control”, BS Publications, 2014.
3. P.M Anderson and A.A Fouad, “Power System Control and Stability”, Iowa State University Press, 2016.
4. PeterW.Sauer&M.A.Pai, “Power System Dynamics & Stability”, Pearson Education, 2015.
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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COURSE OBJECTIVES

To enable the students to

- understand the formulation of research problem.
- learn about data collection and preparation process.
- learn the procedure for literature survey.
- learn the concept of research proposals and research report writing.
- understand about patent rights and its importance.

UNIT I RESEARCH PROBLEM FORMULATION 6

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

UNIT II SCALING AND DATA COLLECTION 6

Quantitative and Qualitative data, Scaling, Scaling Techniques, Experiments and Surveys, Collection of primary and secondary data, Data preparation process.

UNIT III LITERATURE SURVEY 6

Bring clarity and focus to your research problems, Improve your methodology, Procedure for reviewing the literature, search for existing literature, Develop a theoretical and conceptual framework, Writing up the literature reviewed.

UNIT IV RESEARCH PROPOSAL AND RESEARCH REPORT 6

Contents of a research proposal, Writing a research report- Research writing in general, Referencing, Writing a bibliography, Developing an outline, Plagiarism, Research ethics.

UNIT V INTELLECTUAL PROPERTY RIGHTS 6

Intellectual Property- Definition, WTO, Fundamentals of Patent, Copyright- The rights of the owner, Term of copyright, Register of Trademark, Procedure for trade mark, Term of trademark.

TOTAL PERIODS 30

COURSE OUTCOMES

At the end this course, students will be able to

- identify research problems.
- collect and prepare suitable data for research.
- do literature survey in their area of research.

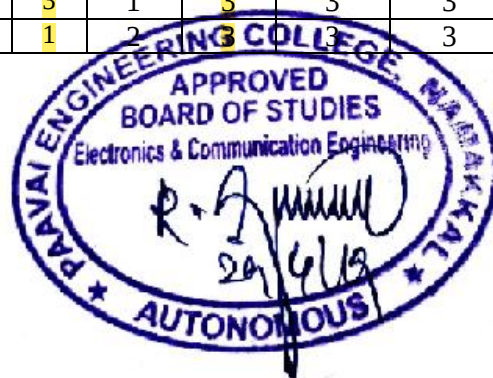
- write research proposals and reports.
- apply their research work for patent through IPR.

REFERENCES

1. C.R Kothari and Gaurav Garg, “Research Methodology Methods and Techniques”, 4th Edition, New Age International Publishers.
2. Ranjit Kumar, “ Research Methodology”, 2nd Edition, Pearson Education, Australia
3. M.N. Borse, “ Hand Book of Research Methodology, Modern, Methods and New Techniques”, Shree Niwas Publications, Jaipur.
4. Neeraj Pandey and Khushdeep Dharni, “ Intellectual Property rights”, PHI Learning, 2014.
5. Dr.R.Radhakrishnan and Dr.S.Balasubramanian, “ Intellectual Property Rights, text and cases”, Excel Books, New Delhi.

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COURSE OBJECTIVES

To enable the students to

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

LIST OF EXPERIMENTS

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

TOTAL PERIODS 60

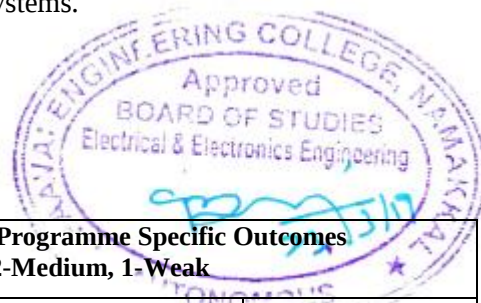
COURSE OUTCOMES

At the end this course, students will be able to

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

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PROFESSIONAL ELECTIVE I

PPS19151 POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS 3 0 0 3

COURSE OBJECTIVES

To enable the students to

- comprehend the electrical energy generation from various renewable and non-renewable sources of energy.
- recognize the fundamental principles of electrical machines in wind energy conversion system and its grid integration with PV systems.
- identify the power converters for wind and solar energy conversion systems Course Outcomes
- perform analysis of wind solar energy systems
- acquire knowledge on hybrid energy systems

UNIT I INTRODUCTION 9

Environmental aspects of electric energy conversion: Impacts of renewable energy generation on environment (cost-GHG Emission) - Qualitative study of different renewable energy resources: Solar, Wind, Ocean, Biomass, Fuel cell, Hydrogen energy systems and Hybrid renewable energy systems.

UNIT II ELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION 9

Review of reference theory fundamentals-Principle of operation and analysis: IG, PMSG, SCIG and DFIG.

UNIT III POWER CONVERTERS 9

Solar: Block diagram of solar photo voltaic system - Principle of operation of line commutated converters (inversion-mode) - Boost and buck-boost converters- selection of inverter, battery sizing, array sizing. Wind: Three phase AC voltage controllers - AC-DC-AC converters, uncontrolled rectifiers, PWM inverters, grid interactive inverters-Matrix converters.

UNIT IV ANALYSIS OF WIND AND PV SYSTEMS SOLAR 9

Stand-alone operation of fixed and variable speed wind energy conversion systems and solar system- Grid connection issues -Grid integrated PMSG and SCIG based WECS-Grid integrated solar system.

UNIT V HYBRID RENEWABLE ENERGY SYSTEMS 9

Need for hybrid systems- Range and type of hybrid systems- Case studies of Wind-PV-Maximum Power Point Tracking (MPPT).

TOTAL PERIODS 45

COURSE OUTCOMES

At the end this course, students will be able to

- describe the power generation from various sources of energy.
- explain the fundamentals and principles of electrical machines in energy conversion.
- analyze the power electronic converters needed for energy conversion applications.
- elucidate the various wind energy systems and PV systems.
- describe the need to extract the maximum power using MPPT algorithm in hybrid systems.

REFERENCES

1. ShobhNath Singh, “Non-conventional Energy resources”, Pearson Education ,2015.
2. S. Sumathi, L. Ashok Kumar , P. Surekha, “Solar PV and Wind Energy Conversion Systems” (Green Energy and Technology), 2015.
3. Rai. G.D, “Solar energy utilization”, Khanna publishes, 2012.
4. Philippe Coiffet, “Robot Technology” Vol. II (Modelling and Control), Prentice Hall Inc, 1983.
5. ShobhNath Singh, “Non-conventional Energy resources”, Pearson Education, 2015.

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COURSE OBJECTIVES

To enable the students to

- understand concept of smart grid, smart meters and its advantages over conventional grid.
- Know smart metering techniques.
- learn wide area measurement techniques.
- understanding the problems associated with integration of distributed generation and its solution through smart grid.
- gain knowledge in communication technologies.

UNIT I INTRODUCTION TO SMART GRID AND SMART METERS 9

Evolution of electric grid, concept of smart grid, definitions and necessity of smart grid, concept of robust and self-healing grid, present development and international policies in smart grid - Real time pricing, smart appliances, automatic meter reading (AMR), outage management system (OMS), smart substations, substation automation, feeder automation.

UNIT II SMART GRID TECHNOLOGIES 9

Geographic information system (GIS), intelligent electronic devices (IED) and their application for monitoring and protection, smart storage like battery, superconducting magnetic energy storage (SMES), wide area measurement system (WAMS), phase measurement unit (PMU).

UNIT III MICRO-GRID 9

Concept, necessity and applications of micro-grid, formation of micro-grid, issues of interconnection, operation, control and protection of micro-grid -Plastic and organic solar cells, thin film solar cells, variable speed wind generators, fuel-cells, micro-turbines, Captive power plants, integration of renewable energy sources.

UNIT IV POWER QUALITY 9

Electromagnetic compatibility (EMC) of smart grid, power quality issues of grid connected renewable energy sources, power quality conditioners for smart grid

UNIT V COMMUNICATIONS IN SMART GRID 9

Advanced metering infrastructure (AMI), home area network (HAN), neighborhood area network, communication through GPRS and power line carrier communication, internet of things (IoT) based protocols.

TOTAL PERIODS 45

COURSE OUTCOMES

At the end this course, students will be able to

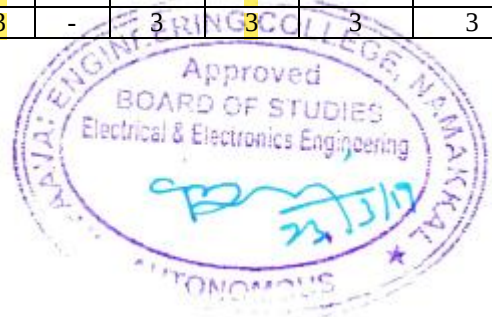
- describe the difference between smart grid and conventional grid.
- apply smart metering concepts to industrial and commercial installations.
- formulate solutions in the areas of smart substations, distributed generation and wide area measurements.
- analyze the issues of power quality in smart grid.
- elucidate the smart grid solutions using modern communication technologies.

REFERENCES

1. Ali Keyhani, “Design of Smart Power Grid Renewable Energy Systems”, 2nd Edn., Wiley IEEE Press.
2. Clark W. Gellings, “The Smart Grid: Enabling Energy Efficiency and Demand Response”, CRC Press, 2009.
3. JanakaEkanayake, KithsiriLiyanage, Jianzhong Wu and Nick Jenkins, “Smart Grid: Technology and Applications”, Wiley Online Library, 2012.
4. Stuart Borlase, “Smart Grid: Infrastructure, Technology and solutions”, CRC Press.
5. AliKeyhani, “Design of Smart Power Grid Renewable Energy Systems”, 2nd Edn., Wiley IEEE Press.

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COURSE OBJECTIVES

To enable the students to

- understand the electrical circuit concepts behind the different working modes of multi-pulse diode rectifier.
- know the different working modes of multilevel concept and applications.
- familiarize in the design and development of DC-DC converters.
- acquire knowledge about various operating modes of different configurations of AC voltage controllers.
- gain information from the concepts of protection of devices and circuits.

UNIT I MULTI-PULSE DIODE RECTIFIER **9**

Multiphase star rectifier, three phase bridge rectifier, three phase bridge rectifier with RL load, three phase rectifier with a highly inductive load - Twelve pulse converters - Effect of load and source inductance.

UNIT II MULTILEVEL INVERTERS **9**

Multilevel concept -Types of multilevel inverters such as: diode clamped multilevel inverter, flying-capacitor multilevel inverter, cascaded multilevel inverter – Applications - PWM current source inverters.

UNIT III DC-DC CONVERTER **9**

Performance parameter of DC-DC converters, Switching mode regulators such as: buck, boost and buck-boost regulators

UNIT IV AC VOLTAGE CONTROLLERS **9**

Performance parameters of AC voltage controllers, single phase full wave controller with resistive loads and inductive loads, three phase full wave controllers, three phase full wave delta connected controllers, Single phase and three phase cycloconverters, matrix converter - Un-interruptible power supply (UPS)

UNIT V PROTECTION OF DEVICES AND CIRCUITS **9**

Cooling and heat sinks, thermal modeling of power switching devices, snubber circuit -Reverse recovery transients, supply and load side transients - Voltage protection by selenium diodes and metal oxide varistors - Current protections, fusing, fault current with AC and DC source.

TOTAL PERIODS 45

COURSE OUTCOMES

At the end this course, students will be able to

- describe the various circuit concepts of multi-pulse diode rectifier.
- analyse the working of multilevel inverter topology.
- design and develop DC-DC converters.
- derive the design criteria and analyse the various operating modes of different configurations of AC voltage controllers.
- provide protection to devices and circuits of various power applications.

REFERENCES

1. Rashid M.H., "Power Electronics Circuits, Devices and Applications", Prentice Hall India, New Delhi, 2014.
2. BimalK.Bose., "Modern Power Electronics and AC Drives", Pearson Education, 2012.
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.
5. P.S.Bimbra, "Power Electronics", Khanna Publishers, 2005.
6. Dubey. G.K., "Thyristorised power controllers", New age International, New Delhi, 2002.

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COURSE OBJECTIVES

To enable the students to

- infer knowledge on renewable energy resources.
- get the concepts of wind energy and its application.
- study characteristics of solar and photovoltaic cell.
- know about power electronics converters.
- understand the fundamental concepts of grid connectors in wind and solar.

UNIT I INTRODUCTION**9**

Environmental aspects of electric energy conversion: Renewable energy resources and their importance - qualitative study of solar PV, wind electrical systems - control strategy, operating area, operating principles and characteristics - Trends in energy consumption - World energy scenario – Energy sources and their availability - Conventional and renewable sources - Need to develop new energy technologies.

UNIT II WIND ENERGY**9**

Introduction - Basic principles of wind energy conversion system - Nature of wind -Site selection consideration -Basic components of wind energy conversion system - Types of wind machines - Basic components of wind electric conversion systems - Schemes for electric generations - Generator control, load control, energy storage -Applications of wind energy - Inter connected systems- Power electronics in wind energy utilization.

UNIT III SOLAR ENERGY**9**

Solar radiation, availability, measurement and estimation - Solar thermal conversion devices and storage, solar cells, solar cell interconnection, solar cell characteristics and photovoltaic conversion -PV systems - Analysis of PV systems- MPPT - Applications of PV Systems - Solar energy collectors and storages - Power electronics in solar energy utilization - DC-DC converters for solar PV systems.

UNIT IV POWER CONVERTERS**9**

Solar: Block diagram of solar photo voltaic system: line commutated converters (inversion mode) - Boost and buck-boost converters- Selection of inverter, battery sizing, array sizing - Wind: three phase AC voltage controllers - AC-DC-AC converters: uncontrolled rectifiers, PWM inverters, grid interactive inverters - Matrix converters.

UNIT V GRID CONNECTED WIND & SOLAR ENERGY CONVERSION SYSTEMS**9**

Grid connectors - Connection issues - Wind farm and its accessories - Grid related problems -

Generator control - Performance improvements - Different schemes - Power converters for Grid connected wind energy conversion system and grid connected solar energy converter systems - Hybrid systems - Types of cogeneration processes.

TOTAL PERIODS 45

COURSE OUTCOMES

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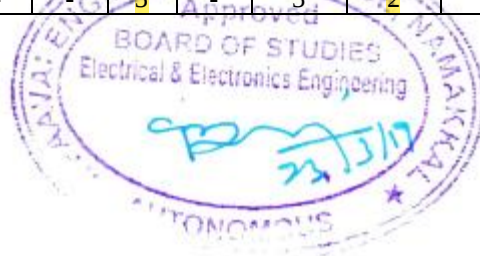
- elucidate renewable energy resources and their importance.
- describe about the basic components in wind energy system.
- analyse the characteristics of solar cell and photovoltaic system.
- explain the modern power converters for renewable energy power harness.
- evaluate grid connection issues and provide performance improvements of wind and solar.

REFERENCES

1. Mukund R. Patel, “Wind and Solar Power Systems: Design, Analysis, and Operation” , Second Edition, CRC Taylor & Francis, 2006.
2. J.A. Duffie and W.A. Beckman, “Solar Engineering of Thermal Processes”, Second Edition, John Wiley, New York, 1991.
3. D.Y. Goswami, F. Kreith and J.F. Kreider, “Principles of Solar Engineering”, Taylor and Francis, Second Edition, 1999.
4. D. D. Hall and R.P. Grover, “Bio-Mass Regenerable Energy” , John Wiley, Newyork, 1987.
5. Haitham Abu-Rub, Mariusz Malinowski, Kamal Al-Haddad, “Power Electronics for Renewable Energy Systems, Transportation and Industrial Applications”, Wiley Publications, 2014.

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



PROFESSIONAL ELECTIVE II

PMA19152 MATHEMATICAL METHODS IN POWER ENGINEERING 3 0 0 3

COURSE OBJECTIVES

To enable the students to

- develop the ability to apply the concepts of matrix theory and linear programming in electrical engineering problems.
- achieve an understanding of the basic concepts of one dimensional random variables and apply in electrical engineering problems.
- familiarize the students in calculus of variations and solve problems using Fourier transforms associated with engineering applications.
- formulate and construct a mathematical model for a linear programming problem in real life situation.
- 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 9

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

UNIT II FOURIER SERIES 9

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.

UNIT III ONE DIMENSIONAL RANDOM VARIABLES 9

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 CALCULUS OF VARIATIONS 9

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 Galerkin methods.

UNIT V LINEAR PROGRAMMING 9

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

TOTAL PERIODS 45

COURSE OUTCOMES

At the end this course, students will be able to

- gain a well found knowledge in matrix to calculate the electrical properties of a circuit, with voltage, amperage ,resistance, etc.
- solve a variational problem using the Euler equation.
- gain knowledge in standard distributions which can describe the real life phenomena.
- understand and apply linear, integer programming to solve operational problem with constraints.
- apply fourier series, their different possible forms and the frequently needed practical harmonic analysis.

REFERENCES

1. Richard Bronson, “Matrix Operation”, Schaum’s outline series, 2nd Edition, McGraw Hill,2011.
2. Gupta, A.S., “Calculus of Variations with Applications”, Prentice Hall of India Pvt. Ltd., NewDelhi, 1777.
3. Oliver C. Ibe, “Fundamentals of Applied Probability and Random Processes”, AcademicPress, (An imprint of Elsevier), 2010.
4. Taha, H.A., “Operations Research, An introduction”, 10th edition, Pearson education,New Delhi, 2010.
5. Andrews L.C. and Phillips R.L., “Mathematical Techniques for Engineers and Scientists”,Prentice Hall of India Pvt.Ltd., New Delhi, 2005.
6. Elsgolts, L., “Differential Equations and the Calculus of Variations”, MIR Publishers, Moscow,1773.
7. Johnson R. A. and Gupta C. B., “Miller & Freund’s Probability and Statistics for Engineers”, Pearson Education, Asia, 7th Edition, 2007.

CO-PO MAPPING:

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

COURSE OBJECTIVES

To enable the students to

- provide knowledge about the distribution system electrical characteristics.
- gain knowledge about planning and designing of distribution system.
- analyze power quality in distribution system.
- understand the voltage regulation in distribution system.
- get idea about the power flow in balanced and unbalanced system.

UNIT I INTRODUCTION 9

Distribution system - Distribution feeder electrical characteristics - Nature of Loads: individual customer load, distribution transformer loading and feeder load - Approximate method of analysis: voltage drop, line impedance, “K” factors, uniformly distributed loads and lumping loads in geometric configurations.

UNIT II DISTRIBUTION SYSTEM PLANNING 9

Factors effecting planning, present techniques, planning models (short term planning, long term planning and dynamic planning), planning in the future, future nature of distribution planning - Role of computer in distribution planning - Load forecast, load characteristics and load models.

UNIT III DISTRIBUTION SYSTEM LINE MODEL 9

Exact line segment model - Modified line model - Approximate line segment model - Modified “Ladder” iterative technique - General matrices for parallel lines.

UNIT IV VOLTAGE REGULATION 9

Standard voltage ratings - Two-winding transformer theory - Two-winding autotransformer - Step-voltage regulators: single-phase step-voltage regulators- Three-phase step-voltage regulators - Application of capacitors in distribution system.

UNIT V DISTRIBUTION FEEDER ANALYSIS 9

Power-flow analysis - Ladder iterative technique - Unbalanced three-phase distribution feeder- modified ladder iterative technique - Load allocation - Short-circuit studies.

TOTAL PERIODS 45

COURSE OUTCOMES

At the end this course, students will be able to

- explain the various types of load and methods of analysis.
- apply the concepts of planning and design of distribution system for utility systems.

- describe about the distribution system line models.
- implement the concepts of voltage control in distribution system.
- analyze the power flow in balanced and unbalanced system.

REFERENCES

1. William H. Kersting, "Distribution System Modeling and Analysis", CRC press 3rd edition, 2016.
2. Turan Gonen, "Electric Power Distribution System Engineering", McGraw Hill Company. 2015
3. Pabla H S, "Electrical Power Distribution Systems", Tata McGraw Hill. 2012
4. James Northcote - Green, Robert Wilson, "Control and Automation of Electrical Power".

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



COURSE OBJECTIVES

To enable the students to

- understand the operation and characteristics of controlled rectifiers.
- know the switching techniques and basic topologies of DC-DC switching regulators.
- analyse the design of power converter components.
- get in depth knowledge about resonant converters.
- comprehend the concepts of AC-AC power converters and their applications.

UNIT I SINGLE PHASE AND THREE PHASE CONVERTERS 9

Principle of phase controlled converter operation - single-phase full converter and semiconverter (RL, RLE load)- single phase dual converter - Three phase operation full converter and semi-converter (R, RL, RLE load) - reactive power - power factor improvement techniques - PWM rectifiers.

UNIT II DC-DC CONVERTERS 9

Limitations of linear power supplies, switched mode power conversion, Non-isolated DC-DC converters: operation and analysis of buck, boost, buck-boost, cuk and SEPIC – under continuous and discontinuous operation - Isolated converters: basic operation of flyback, forward and push-pull topologies.

UNIT III DESIGN OF POWER CONVERTER COMPONENTS 9

Introduction to magnetic materials - Hard and soft magnetic materials – Types of cores , copper windings - Design of transformer - Inductor design equations - Examples of inductor design for buck/flyback converter-Selection of output filter capacitors – Selection of ratings for devices - Input filter design.

UNIT IV RESONANT DC-DC CONVERTERS 9

Switching loss, hard switching, and basic principles of soft switching- classification of resonant converters- load resonant converters – series and parallel – resonant switch converters – operation and analysis of ZVS, ZCS converters comparison of ZCS/ZVS – Introduction to ZVT/ZCT PWM converters.

UNIT V AC-AC CONVERTERS 9

Principle of on-off and phase angle control - single phase ac voltage controller - analysis with R & RL load - Three phase ac voltage controller - principle of operation of cycloconverter - single phase and three phase cycloconverters - Introduction to matrix converters.

TOTAL PERIODS 45

COURSE OUTCOMES

At the end this course, students will be able to

- analyze various single phase and three phase power converters
- design dc-dc converter topologies for a broad range of power conversion applications.
- develop improved power converters for any stringent application requirements.
- design ac-ac converters for variable frequency applications.
- describe the concepts of AC-AC power converters and their applications.

REFERENCES

1. Ned Mohan, T. M. Undeland and W. P. Robbins, "Power Electronics: converters, Application and design" John Wiley and sons, Wiley India edition, 2006.
2. Rashid M.H., "Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Third Edition, New Delhi, 2004.
3. P.C. Sen, "Modern Power Electronics", Wheeler Publishing Co, First Edition, New Delhi, 1998.
4. P.S. Bimbhra, "Power Electronics", Khanna Publishers, Eleventh Edition, 2003
5. Simon Ang, Alejandro Oliva, "Power-Switching Converters, Second Edition, CRC Press, Taylor & Francis Group, 2010
6. V. Ramanarayanan, "Course material on Switched mode power conversion", 2007
7. Alex Van den Bossche and Vencislav Cekov Valchev, "Inductors and Transformers for Power Electronics", CRC Press, Taylor & Francis Group, 2005
8. W. G. Hurley and W. H. Wolfle, "Transformers and Inductors for Power Electronics Theory, Design and Applications", 2013 John Wiley & Sons Ltd.
9. Marian K. Kazimierczuk and Dariusz Czarkowski, "Resonant Power Converters", John Wiley & Sons limited, 2011



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

COURSE OBJECTIVES

To enable the students to

- understand the concepts of conventional vehicles.
- explain and understand depth knowledge in conventional vehicles to infer knowledge in the hybrid electric drive-trains.
- describe the energy storage and energy management.
- discuss the sizing the drive system.
- understand the concepts of conventional vehicles .

UNIT I CONVENTIONAL VEHICLES 9

Basics of vehicle performance - vehicle power source characterization- transmission characteristics- Mathematical models to describe vehicle performance.

UNIT II HYBRID ELECTRIC DRIVE-TRAINS 9

Basic concept of hybrid traction - Introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis - Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.

UNIT III ELECTRIC PROPULSION UNIT 9

Introduction to electric components used in hybrid and electric vehicles, configuration and control of DC motor drives, configuration and control of induction motor drives.

UNIT IV ENERGY STORAGE AND ENERGY MANAGEMENT 9

Introduction to energy storage requirements in hybrid and electric vehicles, battery based energy storage and its analysis, Fuel cell based energy storage and its analysis, hybridization of different energy storage devices - Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies.

UNIT V SIZING THE DRIVE SYSTEM 9

Matching the electric machine and the internal combustion engine (ICE), sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology.

TOTAL PERIODS 45

COURSE OUTCOMES

At the end this course, students will be able to

- elucidate the various method of conventional vehicles

- apply the concepts of various topologies in hybrid electric drive-trains
- describe about the electric propulsion unit
- analyze the energy storage and energy management
- implement the concepts of sizing the drive system

REFERENCES

1. Sira -Ramirez, R. Silva Ortigoza, "Control Design Techniques in Power Electronics Devices", Springer.
2. Siew-Chong Tan, Yuk-Ming Lai, Chi Kong Tse, "Sliding Mode Control of Switching Power Converters".

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



AUDIT I

PEN19171

ENGLISH FOR RESEARCH PAPER WRITING

2 0 0 0

COURSE OBJECTIVES

To enable the students to

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

UNIT I PLANNING AND PREPARATION

6

Precision of Words, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, **Avoiding Ambiguity and Vagueness**. Expressing independent thought with grace, clarity and force.

UNIT II STRUCTURE OF A PAPER

6

Details of all the parts - Clarifying Who Did What, Highlighting the Findings, Hedging and Criticizing, Skills to identify something we really need to know -some ways to find a topic - to venture out across the swamp of research without losing our bearings - **Paraphrasing - Sections of a Paper, Abstract, Introduction. Introduction to Free writing.**

UNIT III LITERATURE REVIEWS AND CITATIONS

6

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

UNIT IV EDITING AND ORGANISING SKILLS

6

Skills required to - write the Methods, write the Discussion, write the Results, **write Conclusions. - write about what we've learned truthfully so the reader really gets it in thought and expression,** demonstrating a clear understanding and execution of the research.

UNIT V WRITING STANDARDS

6

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

TOTAL PERIODS

30

COURSE OUTCOMES

At the end this course, students will be able to

- prepare and write a research paper in their discipline
- be initially organized and well-versed as a researcher, reviewing in detail general versus specific and problem-solution structures.
- understand the basics of citations, avoiding plagiarism and literature reviews.
- culminate the actual crafting and revising of a research paper.
- use suitable vocabulary, grammar and punctuation to write flawless piece of writing.

REFERENCES

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

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



SEMESTER II

PPS19201

ADVANCED POWER SYSTEM PROTECTION

3 0 0 3

COURSE OBJECTIVES

To enable the students to

- understand the characteristics and functions of relays and protection schemes.
- know the concepts of transformer protection and generator protection in faulty conditions.
- acquire knowledge about the usage of relays in distance and carrier protection for single and double end fed lines.
- identify the concepts of bus bar protection under various fault conditions using current transformer.
- be familiar with 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 – Interturn 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 all ten shunt 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 bus bars - 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 bus bar differential scheme - Supervisory relay - Protection of three Phase bus bars.

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 PERIODS 45

COURSE OUTCOMES

At the end this course, students will be able to

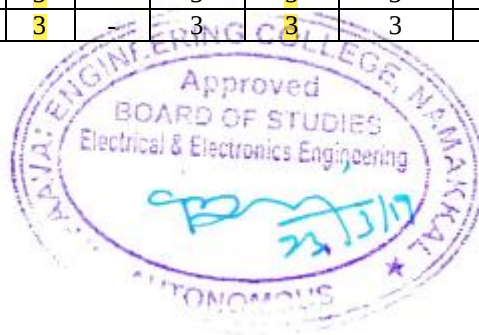
- describe the construction and operation of electromagnetic relays.
- choose the protective circuit based on the knowledge of faults in equipment.
- analyse the usage of relays in distance and carrier protection for single and double end fed lines.
- explain the effective usage of CT in protection circuits.
- perform analysis based on 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 Mc Graw 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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CO4	3	3	3	3	3	-	-	-	3	-	3	3	3	3
CO5	3	3	3	-	3	2	-	-	3	-	3	3	3	3



COURSE OBJECTIVES

To enable the students to

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

UNIT I DC POWER TRANSMISSION TECHNOLOGY 9

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

UNIT II ANALYSIS OF HVDC CONVERTERS AND HVDC SYSTEM CONTROL 9

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

UNIT III MULTITERMINAL DC SYSTEMS 9

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

UNIT IV POWER FLOW ANALYSIS IN AC/DC SYSTEMS 9

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

UNIT V SIMULATION OF HVDC SYSTEMS 9

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

TOTAL PERIODS 45

COURSE OUTCOMES

At the end this course, students will be able to

- describe the basic concept of DC power transmission technology.
- enumerate about HVDC converters and HVDC system control with converter.
- specify the concepts of multi terminal DC systems with control and protection of MTDC

system.

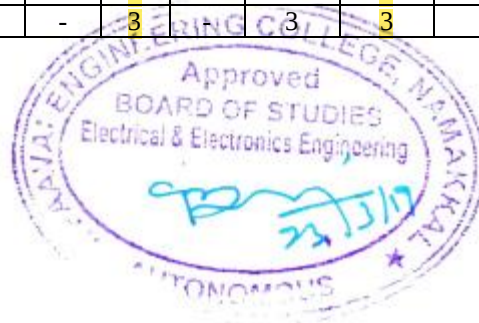
- provide the solution of AC/DC power flow analysis.
- design the simulation of HVDC systems with philosophy and tools.

REFERENCES

1. K.R.Padiyar, "HVDC Power Transmission Systems", New Age International (P) Ltd., New Delhi, 2010.
2. J.Arrillaga, "High Voltage Direct Current Transmission", Peter Pregrinus, London, 1983.
3. P. Kundur, "Power System Stability and Control", McGraw-Hill, 2000.
4. Erich Uhlmann, "Power Transmission by Direct Current", BS Publications, 2004.
5. V.K.Sood, "HVDC and FACTS controllers - Applications of Static Converters in Power System", April 2004, Kluwer Academic Publishers.
6. S.Kakshaish, V.Kamaraju, "HVDC Transmission", TMH Publishers, 2012.

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



COURSE OBJECTIVES

To enable the students to

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

LIST OF EXPERIMENTS

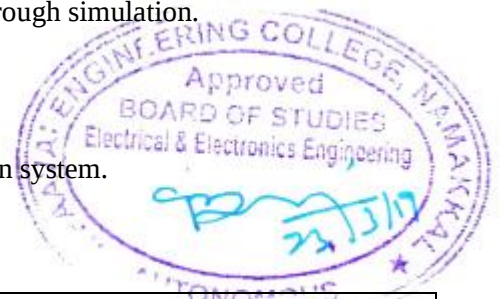
1. Small-signal stability analysis of single machine-infinite bus system using classical machine model.
2. Small-signal stability analysis of multi-machine configuration with classical machine model
3. Induction motor starting analysis
4. Load flow analysis of two-bus system with STATCOM
5. Transient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

TOTAL PERIODS 60

COURSE OUTCOMES

At the end this course, students will be able to

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

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CO4	3	3	3	3	3	-	-	-	3	-	3	3	3	3

COURSE OBJECTIVES

To enable the students to

- develop the ability to implement their engineering knowledge to build products.
- train the students in preparing project reports and to face reviews and viva voce examination.

The student in a group of 3 to 4 works on a topic approved by the Head of the Department under the guidance of a faculty member and prepares a comprehensive project report after completing the work to the satisfaction of the supervisor. The progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The project work is evaluated based on oral presentation and the project report jointly by external and internal examiners constituted by the Head of the Department.

TOTAL PERIODS 60

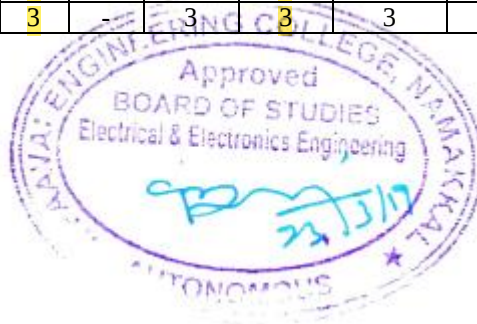
COURSE OUTCOMES

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

- apply the basic fundamentals and concepts of engineering in developing hardware modules.

CO-PO MAPPING:

Mapping of Course Outcome with Programme Outcomes and Programme Specific Outcomes (1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
CO's	Programme Outcomes PO's												PSO's	
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CO1	3	3	3	3	3	-	-	-	-	-	3	3	3	3
CO2	3	3	3	3	3	-	-	-	3	-	3	3	3	3
CO3	3	3	3	3	3	-	-	-	3	-	3	3	3	3
CO4	3	3	3	3	3	-	-	-	3	-	3	3	3	3



PROFESSIONAL ELECTIVE III

PPS19351

RESTRUCTURED POWER SYSTEMS

3 0 0 3

COURSE OBJECTIVES

To enable the students to

- introduce the restructuring of power industry and market models.
- impart knowledge on fundamental concepts of congestion management.
- understand the concepts of locational marginal pricing and financial transmission rights.
- acquire knowledge about various power sectors in India.
- know the reforms in 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 NETWORK 9

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 - **How to obtain ancillary service - Optimization of energy and reserve services - Transmission pricing - Principles** - Classification - Rolled in transmission pricing methods - Marginal transmission pricing paradigm - Composite pricing paradigm - Merits and demerits of different paradigm.

UNIT V REFORMS IN INDIAN POWER SECTOR

9

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 this course, students will be able to

- explain about restructuring of power industry.
- describe the basics of congestion management.
- analyse the locational margin prices and financial transmission rights.
- interpret the ancillary services and pricing of transmission network.
- review the various power sectors in India.

REFERENCES

1. Mohammad Shahidehpour, Muwaffaq Alomoush, Marcel Dekker, “Restructured electrical power systems: operation, trading and volatility” Pub., 2001.
2. Kankar Bhattacharya, Jaap E. Daadler, Math H.J. Boelen, “Operation of restructured power systems”, Kluwer Academic Pub., 2001.
3. Paranjothi, S.R, “Modern Power Systems”, New Age International, 2017.
4. Sally Hunt,” Making competition work in electricity”, John Willey and Sons Inc. 2002.
5. Steven Stoft, “Power system economics: designing markets for electricity”, John Wiley & Sons, 2002.

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

COURSE OBJECTIVES

To enable the students to

- provide in-depth treatment on methods and techniques of digital signal processing
- know the spectrum estimation using non-parametric and parametric methods
- understand power spectrum estimation, multi-rate digital signal processing.
- have an insight on DSP architectures which are of importance in the areas of signal processing, control and communications.
- impart knowledge on multi-rate signal processing

UNIT I	DISCRETE RANDOM SIGNAL PROCESSING	9
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Weiner Khitchine relation – Power spectral density – Filtering random process, spectral factorization theorem, special types of random process - Signal modeling - Least Squares method, Pade approximation, Prony's method, iterative pre-filtering, finite data records, stochastic models.

UNIT II SPECTRUM ESTIMATION 9

Non-Parametric methods - Correlation method - Co-variance estimator - Performance analysis of estimators - Unbiased consistent estimators - Periodogram estimator - Barlett spectrum estimation - Welch estimation - Model based approach - AR, MA, ARMA signal modeling - Parameter estimation using Yule-Walker method.

UNIT III LINEAR ESTIMATION AND PREDICTION 9

Maximum likelihood criterion - Efficiency of estimator - Least mean squared error criterion - Wiener filter - Discrete Wiener Hoff equations - Recursive estimators - Kalman filter - Linear prediction, prediction error - Whitening filter, inverse filter - Levinson recursion, Lattice realization, Levinson recursion algorithm for solving Toeplitz system of equations.

UNIT IV ADAPTIVE FILTERS 9

FIR Adaptive filters - Newton's steepest descent method - Adaptive filters based on steepest descent method - Widrow Hoff LMS adaptive algorithm - Adaptive channel equalization - Adaptive echo canceller - Adaptive noise cancellation - RLS adaptive filters - Exponentially weighted RLS - Sliding window RLS - Simplified IIR LMS Adaptive filter.

UNIT V MULTIRATE DIGITAL SIGNAL PROCESSING 9

Mathematical description of change of sampling rate - Interpolation and decimation - Continuous time model - Direct digital domain approach - Decimation by integer factor - Interpolation by an integer factor - **Single and multistage realization - Poly phase realization** - Applications to sub band coding -

COURSE OUTCOMES

At the end this course, students will be able to

- review the basis of discrete signal processing
- perform spectrum estimation using non-parametric and parametric methods
- carry out power spectrum estimation, multi-rate digital signal processing.
- identify DSP architectures for various applications
- design multi-rate DSP systems

REFERENCES

1. Monson H. Hayes, “Statistical Digital Signal Processing and Modeling”, John Wiley and Sons Inc., New York, 2016.
2. Sophoncles J. Orfanidis, “Optimum Signal Processing”, McGraw-Hill, 2014.
3. John G. Proakis, Dimitris G. Manolakis, “Digital Signal Processing”, Prentice Hall of India, New Delhi, 2015.
4. Simon Haykin, “Adaptive Filter Theory”, Prentice Hall, Englewood Cliffs, NJ Reprint 2014.
5. S. Kay, “Modern Spectrum Estimation Theory And Application”, Prentice Hall, Englewood Cliffs, NJ reprint 2015.
6. P. P. Vaidyanathan, “Multi-rate Systems And Filter Banks”, Prentice Hall, Reprint 2016.

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



COURSE OBJECTIVES

To enable the students to

- understand the principle of co-energy.
- know the working of basic two pole machine.
- transform a machine between reference frames.
- analyze induction and asynchronous machine
- analyze induction and synchronous machine.

UNIT I BASIC PRINCIPLES OF ELECTRICAL MACHINE ANALYSIS 9

Operation and steady state behavior of electrical machines: Magnetically coupled circuits - Electromechanical conversion - Principles of energy flow - Steady state equations of dc machines - rotating field theory - Operation of induction motor – Operation of synchronous motor – Power angle characteristics.

UNIT II THEORY OF TWO POLE MACHINE 9

Elements of generalized theory basic two pole machine - Transformer and speed voltages in the armature - Kron's primitive machine - Analysis of electric machines.

UNIT III REFERENCE FRAME THEORY 9

Linear transformation in machines - Invariance of power, transformation from a displayed brush axis - Reference theory transformation from three phases to two phases, (α - β and d-q transformation) - Physical concept of Park's transformation - Transformation between reference frames.

UNIT IV MODELING AND ANALYSIS OF ASYNCHRONOUS MACHINES 9

Poly phase induction machines - Mathematical modeling of induction machines - Voltage and torque equations in machine variables, induction machine dynamics during starting and braking - Induction machine dynamics during normal operation.

UNIT V MODELING AND ANALYSIS OF SYNCHRONOUS MACHINES 9

Synchronous motor - Circuit model of a three phase synchronous motor, flux linkages voltage equations – Parks transformation to dq0 variables - Electromechanical equation - Motor operation - generator operation - Small oscillations - General equations for small oscillations.

TOTAL PERIODS 45

COURSE OUTCOMES

At the end this course, students will be able to

- explain the basis of electrical machines and steady state analysis.

- analyze different control theories.
- model and simulate AC machines for further studies.
- utilize BLDC and SRM motors.
- design induction machine for starting, accelerating and braking with respect to rotor resistance.

REFERENCES

1. Werner Leonhard, "Control of Electrical Drives", Springer; 3rd edition, 2001.
2. D. P. Sen Gupta and J. W. Lynn, "Electrical Machine Dynamics", The Macmillan Press, 1980.
3. T.J.E Miller, "Brushless permanent Magnet & Reluctance Motor Drives" Clarendon press, Oxford 1989.
4. Kenjo T and Nagamoris "Permant Magnet & brushless Dc motor" , Clarendon press, Oxford, 1989.

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



COURSE OBJECTIVES

To enable the students to

- know about solar energy storage systems
- understand the basic knowledge on standalone PV system
- recognize the issues in grid connected PV systems
- identify different energy storage systems and analyze their performances
- get knowledge on different applications using solar energy

UNIT I INTRODUCTION**9**

Characteristics of sunlight - Semiconductors and PN junctions - Behavior of solar cells - Cell properties
- PV cell interconnection

UNIT II STAND ALONE PV SYSTEM**9**

Solar modules - Storage systems - Power conditioning and regulation - MPPT- Protection - Standalone
PV systems design - Sizing

UNIT III GRID CONNECTED PV SYSTEMS**9**

PV systems in buildings - Design issues for central power stations - Safety - Economic aspect
efficiency and performance - International PV programs

UNIT IV ENERGY STORAGE SYSTEMS**9**

Impact of intermittent generation - Battery energy storage - Solar thermal energy storage - Pumped
hydroelectric energy storage

UNIT V APPLICATIONS**9**

Water pumping - Battery chargers - Solar car - Direct-drive applications - Space -
Telecommunications.

TOTAL PERIODS 45**COURSE OUTCOMES**

At the end this course, students will be able to

- describe about solar energy storage systems
- illustrate the basic knowledge on standalone PV system
- analyze the issues in grid connected PV systems
- model different energy storage systems and analyze their performances
- implement different applications using solar energy

REFERENCES

1. Solanki C.S., “Solar Photovoltaics: Fundamentals, Technologies And Applications”, PHI Learning Pvt. Ltd.,2015.
2. Stuart R.Wenham, Martin A.Green, Muriel E. Watt and Richard Corkish, “AppliedPhotovoltaics”, 2007,Earthscan, UK.
3. Eduardo Lorenzo G. Araujo, “Solar electricity engineering of photovoltaic systems”, Progensa,1994.
4. Frank S. Barnes & Jonah G. Levine, “Large Energy storage Systems Handbook”, CRC Press, 2011.
5. McNeils, Frenkel, Desai, “Solar & Wind Energy Technologies”, Wiley Eastern, 1990
6. S.P. Sukhatme , “Solar Energy”, Tata McGraw Hill,1987.

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



PROFESSIONAL ELECTIVE IV

PPS19451

ADVANCED MICROCONTROLLER BASED SYSTEMS

3 0 0 3

COURSE OBJECTIVES

To enable the students to

- understand the concept of microcontroller and its peripherals function.
- infer the architecture and processor of CORTEX M
- recognise the advanced concept of embedded C
- know the features of STM32F4xx.
- acquire knowledge on STM32F4 peripherals and programming

UNIT I ADVANCED CONCEPTS IN 8051 ARCHITECTURE

9

Review of 8051 architecture, concept of synchronous serial communication, SPI and I2C communication protocols, study of SPI port on 89LP 51RD2, study of SAR ADC/DAC MCP3304 / MCP 33, interfacing concepts for SPI based ADC/DAC, study of watchdog timer, study of PCA timer in different modes like capture mode, PWM generation mode, High speed output toggle mode Embedded 'C' programming for the above peripherals atirices.

UNIT II INTRODUCTION TO ARM CORTEX M PROFILE

9

CORTEX M0 and M4 cores, Harvard and Von Neumann architectures, CPU Registers, CPU Operating Modes, Thumb-2 Instruction Set, Memory Map, Bus Interface, bit bending , interrupt handling ,NVIC(Nested Vectored Interrupt Controller), system tick timer, Debug system

UNIT III ADVANCED CONCEPTS IN EMBEDDED 'C' PROGRAMMING

9

Pointers, structures, unions, pointers to structures, pointers to functions, addressing mechanism for memory mapped registers, enumerators, Interrupt Handlers, Embedded software architecture: Round robin architecture, Round robin with interrupt architecture

UNIT IV INTRODUCTION TO STM32F4XX ARCHITECTURE

9

Features of STM32F4XXDSC, Memory and bus architecture, Multilevel AHB bus matrix, Memory organization, Memory map, NVIC Operation Exception Entry And Exit , Reset and Clock Circuit

UNIT V STM32F4 PERIPHERALS AND PROGRAMING

9

GPIO, General Purpose Timers, GPIO :Introduction, Main Features , Function Description, Registers, Basic timers (TIM6&TIM7): introduction, main features, functional description, registers Embedded C Programming for GPIO and Timers

TOTAL PERIODS 45

COURSE OUTCOMES

At the end this course, students will be able to

- describe the working of microcontroller and its peripherals functions.
- enumerate the architecture and processor of CORTEX M
- program an embedded system in assembly and C
- design to implement and test a single-processor embedded systems for real-time applications
- optimizing embedded software for speed and size for industrial applications.

REFERENCES

1. Datasheet of 89V51RD2 (www.nxp.com, www.atmel.com)
2. Datasheet MCP3304/MCP4822 (www.microchip.com)
3. The 8051 Microcontroller and Embedded Systems Using Assembly and C, By Muhammad Ali Mazidi, Janice GillispieMazidi, RolinMcKinlay
4. David E. Simon. “An Embedded Software Primer” Addison Wesley Pearson Education, 1999.
5. “The Definitive Guide to ARM® CORTEX®-M3 and CORTEX®-M4 Processors (Third Edition)”, By Joseph Yiu, Newnes, Elsevier
6. “The insider’s guide to the STM32 ARM based Microcontroller”, (www.hitex.com)
7. Datasheet, programming and user reference manual of STM32F4xx (www.st.com)
8. “The Designer's Guide to the Cortex-M Processor Family: A Tutorial Approach”, By Trevor Martin, Newnes, Elsevier

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CO5	3	3	3	3	3	-	-	-	3	-	3	3	3	3



COURSE OBJECTIVES

To enable the students to

- gain knowledge of basics and configurations of SCADA System.
- understand the architecture and types of SCADA system
- evaluate the vulnerability and security methods of SCADA system.
- infer knowledge on the communication protocols for SCADA interface.
- acquire knowledge of various skills necessary for Industrial applications of SCADA.

UNIT I SCADA IN POWER SYSTEMS 9

Introduction to supervisory control and data acquisition, SCADA functional requirements and components, general features, functions and applications, benefits - Configurations of SCADA, RTU (Remote Terminal Units) connections, SCADA communication requirements

UNIT II ARCHITECTURE AND TYPES 9

SCADA system architecture, interfacing SCADA with PLC; Types: First Generation: Monolithic or Early SCADA systems - Second Generation: Distributed SCADA systems - Third Generation: Networked SCADA systems - Fourth Generation: Internet of things technology, SCADA systems.

UNIT III EVOLUTION OF SCADA PROTOCOLS 9

Background technologies of the SCADA protocols, Structure of a SCADA Communications Protocol, SCADA protocols: IEC 60870-5, the MODBUS model, the DNP3 protocols, RP 750, profibus, conitel and the security implications of the SCADA protocols.

UNIT IV SCADA VULNERABILITIES AND ATTACKS AND SECURITY METHODS AND TECHNIQUES 9

The myth of SCADA invulnerability, SCADA risk management components, assessing the risk, mitigating the risk, SCADA threats and attack routes. SCADA security methods and techniques: SCADA security mechanisms, SCADA intrusion detection systems and SCADA security standards.

UNIT V APPLICATIONS 9

SCADA for power generating stations, SCADA for power distribution systems, manufacturing industries, waste water treatment and distribution plants, SCADA in power system, power system automation and wireless SCADA.

TOTAL PERIODS 45

COURSE OUTCOMES

At the end this course, students will be able to

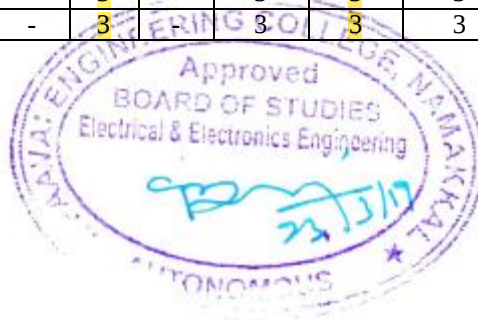
- explain the basics and configurations of SCADA systems applied to power systems.
- describe the architecture and types of SCADA system components.
- describe and access the risk of vulnerability and security methods.
- demonstrate the knowledge of communication protocols for data transmission.
- design and analyze the general structure of an automated process for real time industrial applications using SCADA.

REFERENCES

1. Ronald L Krutz, “Securing SCADA System”, Wiley Publication, 2015.
2. Stuart A Boyer, “SCADA Supervisory Control and Data Acquisition”, ISA, 4th Revised Edition, 2009.
3. A.S. Pabla, ‘Electric Power Distribution’, Tata McGraw Hill Publishing Co. Ltd., Fourth Edition, 2004.
4. Green, J. N, Wilson, R, “Control & Automation of Electric Power Distribution Systems”, Taylor & Francis, 2007.
5. Tanuj Kumar Bisht, “SCADA and Energy Management System”, 2014.

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



COURSE OBJECTIVES

To enable the students to

- understand the concepts of the power quality issues.
- know the concept of long and short interruptions.
- infer knowledge in the single phase voltage sag.
- specify the power quality considerations in industries.
- recognize the mitigation of interruptions and voltage sags.

UNIT I INTRODUCTION**9**

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 AND SHORT INTERRUPTIONS**9**

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 SINGLE AND THREE PHASE VOLTAGE SAG CHARACTERIZATION**9**

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**9**

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 AND VOLTAGE SAGS

9

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 PERIODS 45

COURSE OUTCOMES

At the end this course, students will be able to

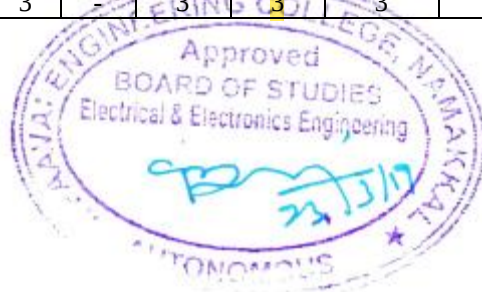
- elucidate the various power quality issues.
- explain the concept of long and short interruptions.
- explain the concept of single and three phase voltage sag.
- implement the power quality considerations in industrial power.
- describe the concept of mitigation of interruptions and voltage sags.

REFERENCES

1. Math H J Bollen , “Understanding Power Quality Problems” , IEEE Press, 2016.
2. R. Sastry Vedom Mulukutla S. Sarma , - “Power Quality VAR Compensation in Power Systems”, CRC Press, 2016.
3. C. Sankaran, - “Power Quality”, CRC Press, 2011.
4. Roger C. Dugan , Mark F.McGranaghan, H. Wayne Beaty, - “Electrical Power Systems Quality” , Tata McGraw Hill , 2012

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



COURSE OBJECTIVES

To enable the students to

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

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 particle swarm optimization and differential evolution techniques - Formulation, applications.

TOTAL PERIODS 45

COURSE OUTCOMES

At the end this course students will be able to

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

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2. GeorgeKlir and Tina Folger,.A., - “Fuzzy sets, Uncertainty and Information”, Prentice Hall of India Pvt.Ltd., 2002 .
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4. IEEE tutorial on – “Application of Neural Network to Power Systems”, 2010
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CO-PO MAPPING

Mapping of Course Outcome with Programme Outcomes and Programme Specific Outcomes (1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
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CO3	3	3	3	-	3	-	-	-	3	-	3	3	3	3
CO4	3	3	3	3	3	-	-	-	3	-	3	3	3	3
CO5	3	3	3	-	-	2	-	-	3	-	3	3	3	3



AUDIT II

PEN19271

PEDAGOGY STUDIES

2 0 0 0

COURSE OBJECTIVES

To enable the students to

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

UNIT I EDUCATION AND ITS PHILOSOPHY

6

Education- Definition, Aims, Objectives, Scope, Educational philosophy of Swami Vivekananda, Mahatma Gandhi, Rabindranath Tagore, Sri Aurobindo and J.Krishnamoorthy, Montessori, Jean- Jacques Rousseau, Friedrich Froebel and John Dewey. Current trends and issues in Education-

Educational reforms and National policy on Education-1968 and 1986-its objectives and features

UNIT II INSTRUCTIONAL OBJECTIVES AND DESIGN

8

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

UNIT III INSTRUCTIONAL METHODS AND STRATEGIES

6

Instructional strategies – Lecture, demonstration, laboratory, Inductive method, Deductive method, Inquiry method, seminar, panel discussion, symposium, problem solving, project based learning (PBL), Learning by doing, workshop, role- play(socio-drama), Recent trends: Constructivist learning - Problem-based learning - Brain-based learning – Collaborative learning - Flipped learning - Blended learning - e-Learning trends - Video conferencing

UNIT IV INSTRUCTIONAL MEDIA

6

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

UNIT V TEACHER PREPARATION

4

Teacher – roles and responsibilities, functions, characteristics, competencies, qualities, Preparation of professional teacher, Organizing professional aspects of teacher preparation programs, Professional

development of teachers-In-service training, Refresher programmes, workshop and higher studies.

TOTAL PERIODS

30

PRACTICUM

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

COURSE OUTCOMES

At the end this course, students will be able to

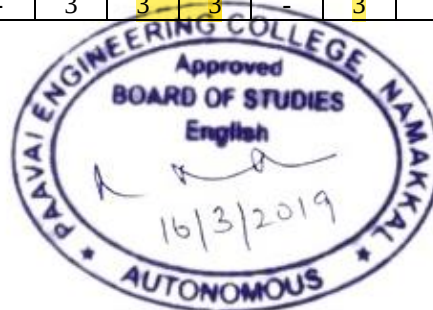
- explain the educational philosophies of education
- write instructional and specific objectives in lesson plan
- utilize the teaching skills and methods effectively
- use instructional media efficiently
- update themselves in the area of professional development

REFERENCES

1. T V Somashekar, G Viswanathappa and Anice James (2014), Methods of Teaching Mathematics, Hyderabad, Neelkamal publications Pvt Ltd
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3. Batra, P. (2010). Social science learning in schools: Perspectives and challenges. New Delhi: Sage publications India.
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6. Karthikeyan, C. (2004). A Text book on instructional technology, RBSA
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12. Sharma, R.A. (2008). Technological foundation of education. Meerut: Lall Books Depot.

CO-PO MAPPING

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CO3	-	-	-	-	-	-	-	3	2	3	-	3	-	-
CO4	-	-	-	-	1	-	-	-	3	3	-	3	-	-
CO5	-	-	-	-	-	-	-	3	3	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 NETWORK 9

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.

REFERENCES

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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



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.

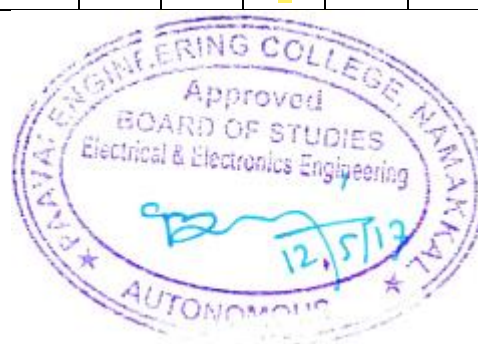
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1. Amirnaser Yezdani, and Reza Iravani, "Voltage Source Converters in Power Systems: Modeling, Control and Applications", IEEE John Wiley Publications, 2009.
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2. www.egr.msu.edu/~mitraj/misc/Mitra_seminar_LANL.pdf
3. <https://www.ee.iitb.ac.in/wiki/faculty/sak>

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

REFERENCES

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2. J. Duncan Glover, Mulukutla S. Sarma, Thomas Overbye, "Power System Analysis and Design", 2011.
3. Patrick H Garrett, "High performance Instrumentation and Automation", CRC Press, Taylor & Francis Group, 2005.

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2. books.google.com > ... > Power Resources > Electrical
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4. www.gbv.de/dms/ilmenau/toc/593623495.PDF

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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



ELECTIVE V

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 VOLTAGE STABILITY ANALYSIS 9

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 SUB SYNCHRONOUS RESONANCE 9

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.
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WEB LINKS

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CO5	3	-	3	2	3	1	-	1	-	2	-	2	2	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 AREA MEASUREMENT 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, IEEE C37.118 (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.
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WEB LINKS

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3. nptel.ac.in/courses/102103044/pdf/mod6.pdf

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



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.

WEB LINKS

1. www.crcpress.com/Computer-Aided-Power-Systems-Analysis-Second-Edition/Kusic/p/book/9781420061062
2. <https://www.scribd.com/.../Computer-Aided-Power-Systems-Analysis>.
3. <http://nptel.ac.in/courses/108107028/5>

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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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



ELECTIVE VI

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 CONCEPTS 9

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.
6. Marc Madou, “Fundamentals of micro fabrication”,CRC Press, 1997.

WEB LINKS

1. www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA429659
2. www.engr.uvic.ca/~mech466/MECH466-Lecture-8.pdf
3. www.engr.uvic.ca/~mech466/MECH466-Lecture-6.pdf

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



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. Eshraghian, 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.
4. S.M. Sze, "VLSI Technology", McGrawHill, Deluxe Edition, 2010.
5. Douglas Perry, „VHDL Programming By Example“, Tata McGraw Hill, 2007.
6. John P.Uyemura "Introduction to VLSI Circuits and Systems", John Wiley & Sons, Inc., 2002.

WEB LINKS

1. <https://docs.google.com/file/d/0B9LJy8vattSMWxOMDl1Sk43Sjg/edit>
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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CO4	3	-	3	-	3	-	-	1	-	2	-	2	3	1
CO5	3	-	3	-	3	-	-	1	-	2	-	2	3	1



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 ACQUISITION**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

REFERENCES

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.

WEB LINKS

1. www.ni.com/labview/
2. <https://www.ni.com/getting-started/set-up-hardware/>
3. www.ni.com/pdf/manuals/370426n.pdf

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