**JNTUH COLLEGE OF ENGINEERING HYDERABAD (AUTONOMOUS)**

**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

**B.Tech. (Reg)-ELECTRICAL AND ELECTRONICS ENGINEERING**

**(Applicable from the batch admitted during 2021-22 and onwards)**

**III YEAR I SEMESTER**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S. No.** | **Course Code** | **Course Title** | **L** | **T** | **P** | **Credits** |
| 1 | PCC-9 | Power Electronics | 3 | 1 | 0 | 4 |
| 2 | PCC-10 | Power System-II | 3 | 1 | 0 | 4 |
| 3 | PCC-11 | Digital Signal Processing | 3 | 1 | 0 | 4 |
| 4 | PEC-I | Professional Elective-I | 3 | 0 | 0 | 3 |
| 5 | PCC-12 | Microprocessors & Microcontrollers | 3 | 0 | 0 | 3 |
| 6 | PCC-LC | Microprocessors & Microcontrollers Lab | 0 | 0 | 2 | 1 |
| 7 | PCC-LC | Power Electronics Lab | 0 | 0 | 2 | 1 |
| 8 | PCC-LC | Digital Signal Processing Lab | 0 | 0 | 2 | 1 |
| 9 | HSMC | Advanced English Communication Skills Lab | 0 | 0 | 2 | 1 |
| 10 | \*MC | Introduction to Cyber security | 2 | 0 | 0 | 0 |
|  |  | **Total Credits** |  |  |  | **22** |

**III YEAR II SEMESTER**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S. No** | **Course Code** | **Course Title** | **L** | **T** | **P** | **Credits** |
| 1 | OEC-I | Open Elective-I | 3 | 0 | 0 | 3 |
| 2 | PEC-II | Professional Elective-II | 3 | 0 | 0 | 3 |
| 3 | HSMC | Business Economics and Financial Analysis | 3 | 0 | 0 | 3 |
| 4 | PCC-13 | Power Electronic Applications to Power systems | 3 | 0 | 0 | 3 |
| 5 | PCC-14 | Power System Protection  | 3 | 1 | 0 | 4 |
| 6 | PCC-15 | Power System Operation and Control | 3 | 0 | 0 | 3 |
| 7 | PCC-LC | Power System Lab | 0 | 0 | 2 | 1 |
| 8 | PCC-LC | Electrical Simulation Lab | 0 | 0 | 2 | 1 |
| 9 | PCC-LC | Power Electronic Applications Lab | 0 | 0 | 2 | 1 |
| 10 | \*MC | Introduction to Artificial Intelligence | 2 | 0 | 0 | 0 |
|  |  | **Total Credits** |  |  |  | **22** |

**Open Elective-I:**

1. Renewable Energy Sources

**Open Elective-II:**

1. Utilization of Electric Energy

**Open Elective-III:**

1. Energy Sources & Applications

**Professional Elective-I:**

1. Computer Architecture
2. High Voltage Engineering
3. Electric Machine Design

**Professional Elective-II:**

1. Signals and Systems
2. Power Semiconductor Drives
3. Power Quality

**Professional Elective-III:**

1. Digital Control systems
2. Optimization Techniques
3. Hybrid Electric Vehicles

**Professional Elective-IV:**

1. Non-Conventional Energy Sources
2. Power System Reliability
3. Industrial Electrical Systems

**Professional Elective-V:**

1. Wind andSolar EnergySystems
2. Control System Design
3. AI Techniques in Electrical Engineering

**Professional Elective-VI:**

1. Smart Grid Technologies
2. Electrical Distribution Systems
3. Advanced Control of Electric Drives

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**RENEWABLE ENERGY SOURCES**

**(Open Elective-I)**

**Pre-requisites:** None

**Course Objectives:**

* To recognize the awareness of energy conservation in students
* To identify the use of renewable energy sources for electrical power generation
* To collect different energy storage methods
* To detect about environmental effects of energy conversion

**Course Outcomes:** At the end of the course the student will be able to:

* Understand the principles of wind power and solar photovoltaic power generation, fuel cells.
* Assess the cost of generation for conventional and renewable energy plants
* Design suitable power controller for wind and solar applications
* Analyze the issues involved in the integration of renewable energy sources to the grid

**UNIT-I:**

**INTRODUCTION**

Renewable Sources of Energy-Grid-Supplied Electricity-Distributed Generation-Renewable Energy Economics-Calculation of Electricity Generation Costs –Demand side Management Options –Supply side Management Options-Modern Electronic Controls of Power Systems.

**WIND POWER PLANTS:**

Appropriate Location -Evaluation of Wind Intensity -Topography -Purpose of the Energy Generated -General Classification of Wind Turbines-Rotor Turbines-Multiple-Blade Turbines Drag Turbines -Lifting Turbines-Generators and Speed Control used in Wind Power Energy Analysis of Small Generating Systems.

**UNIT-II:**

**PHOTOVOLTAIC POWER PLANTS**

Solar Energy-Generation of Electricity by Photovoltaic Effect -Dependence of a PV Cell Characteristic on Temperature-Solar cell Output Characteristics-Equivalent Models and Parameters for Photovoltaic Panels-Photovoltaic Systems-Applications of Photovoltaic Solar Energy-Economical Analysis of Solar Energy.

**FUEL CELLS:** The Fuel Cell-Low and High Temperature Fuel Cells-Commercial and Manufacturing Issues Constructional Features of Proton Exchange-Membrane Fuel Cells –Reformers-Electrolyzer Systems and Related Precautions-Advantages and Disadvantages of Fuel Cells-Fuel Cell Equivalent Circuit-Practical Determination of the Equivalent Model Parameters -Aspects of Hydrogen as Fuel.

**UNIT-III:**

**INDUCTION GENERATORS**

Principles of Operation-Representation of Steady-State Operation-Power and Losses Generated-Self-Excited Induction Generator-Magnetizing Curves and Self-Excitation Mathematical Description of the Self-Excitation Process-Interconnected and Stand-alone operation -Speed and Voltage Control -Economical Aspects.

**UNIT-IV:**

**STORAGE SYSTEMS**

Energy Storage Parameters-Lead–Acid Batteries-Ultra Capacitors-Flywheels –Superconducting Magnetic Storage System-Pumped Hydroelectric Energy Storage - Compressed Air Energy Storage -Storage Heat -Energy Storage as an Economic Resource.

**UNIT-V:**

**INTEGRATION OF ALTERNATIVE SOURCES OF ENERGY**

Principles of Power Injection-Instantaneous Active and Reactive Power Control Approach Integration of Multiple Renewable Energy Sources-Islanding and Interconnection Control-DG Control and Power Injection.

**INTERCONNECTION OF ALTERNATIVE ENERGY SOURCES WITH THE GRID:**

Interconnection Technologies -Standards and Codes for Interconnection-Interconnection Considerations -Interconnection Examples for Alternative Energy Sources.

**TEXT BOOKS:**

1. Felix A. Farret, M. Godoy Simoes, “Integration of Alternative Sources of Energy”, John Wiley& Sons, 2006.
2. Solanki: Renewable Energy Technologies: Practical Guide ForBeginneers, PHI Learning Pvt. Ltd., 2008.

**REFERENCES:**

1. D.Mukherjee: Fundamentals of Renewable Energy Systems, New Age International publishers, 2007.
2. Remus Teodorescu, Marco Liserre, Pedro Rodríguez: Grid Converters for Photovoltaic and Wind Power Systems, John Wiley & Sons, 2011.
3. Gilbert M. Masters: Renewable and Efficient Electric Power Systems, John Wiley & Sons, 2004.

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**SIGNALS AND SYSTEMS**

**(Professional Elective-II.1)**

**Prerequisite**: Digital Signal Processing, Control Systems, Laplace Transforms, Numerical Methods and Complex variables

**Course Objectives:**

* To develop ability to analyze linear systems and signals
* To develop critical understanding of mathematical methods to analyze linear systems and signals
* To know the various transform techniques
* To analyze sampling principles

**Course Outcomes:** At the end of this course, students will demonstrate the ability to

* Understand the concepts of continuous time and discrete time systems.
* Analyze systems in complex frequency domain.
* Understand sampling theorem and its implications.

**UNIT-I:**

**INTRODUCTION TO SIGNALS AND SYSTEMS**

Signals and systems as seen in everyday life, and in various branches of engineering and science. Signal properties: periodicity, absolute integrability, determinism and stochastic character. Some special signals of importance: the unit step, the unit impulse, the sinusoid, the complex exponential, some special time-limited signals; continuous and discrete time signals, continuous and discrete amplitude signals. System properties: linearity: additivity and homogeneity, shift-invariance, causality, stability, reliability. Examples.

**UNIT-II:**

**BEHAVIOR OF CONTINUOUS AND DISCRETE-TIME LTI SYSTEMS**

Impulse response and step response, convolution, input-output behavior with aperiodic convergent inputs, cascade interconnections. Characterization of causality and stability of LTI systems. System representation through differential equations and difference equations. State-space Representation of systems. State-Space Analysis, Multi-input, multi-output representation. State Transition Matrix and its Role. Periodic inputs to an LTI system, the notion of a frequency response and its relation to the impulse response.

**UNIT-III:**

**FOURIER TRANSFORMS**

Fourier series representation of periodic signals, Waveform Symmetries, Calculation of Fourier Coefficients. Fourier Transform, convolution/multiplication and their effect in the frequency domain, magnitude and phase response, Fourier domain duality. The Discrete Time Fourier Transform (DTFT) and the Discrete Fourier Transform (DFT). Parseval's Theorem.

**UNIT-IV:**

**LAPLACE AND Z- TRANSFORMS**

Review of the Laplace Transform for continuous time signals and systems, system functions, poles and zeros of system functions and signals, Laplace domain analysis, solution to differential equations and system behavior. The z-Transform for discrete time signals and systems, system functions, poles and zeros of systems and sequences, z-domain analysis.

**UNIT-V:**

**SAMPLING AND RECONSTRUCTION**

The Sampling Theorem and its implications. Spectra of sampled signals. Reconstruction: ideal interpolator, zero-order hold, first-order hold. Aliasing and its effects. Relation between continuous and discrete time systems. Introduction to the applications of signal and system theory: modulation for communication, filtering, feedback control systems.

**TEXT BOOKS:**

1. A. V. Oppenheim, A. S. Willsky and S. H. Nawab, “Signals and systems”, Prentice Hall India, 1997.
2. J. G. Proakis and D. G. Manolakis, “Digital Signal Processing: Principles, Algorithms, and Applications”, Pearson, 2006.

**REFERENCES:**

1. H. P. Hsu, “Signals and systems”, Schaum’s series, McGraw Hill Education, 2010.
2. S. Haykin and B. V. Veen, “Signals and Systems”, John Wiley and Sons, 2007.
3. A. V. Oppenheim and R. W. Schafer, “Discrete-Time Signal Processing”, Prentice Hall, 2009.
4. M. J. Robert “Fundamentals of Signals and Systems”, McGraw Hill Education, 2007.
5. B. P. Lathi, “Linear Systems and Signals”, Oxford University Press, 2009.

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###### POWER SEMICONDUCTOR DRIVES

**(Professional Elective-II.2)**

**Prerequisite**: Power Electronics, Electrical Machines – I, Electrical Machines – II

**Course Objectives:**

* To introduce the drive system and operating modes of drive and its characteristics
* To understand Speed – Torque characteristics of different motor drives by various power converter topologies
* To appreciate the motoring and braking operations of drive
* To differentiate DC and AC drives

**Course Outcomes:** After completion of this course the student is able to

* Identify the drawbacks of speed control of motor by conventional methods.
* Differentiate Phase controlled and chopper-controlled DC drives speed-torque characteristics merits and demerits
* Understand Ac motor drive speed–torque characteristics using different control strategies its merits and demerits
* Describe Slip power recovery schemes

**UNIT-I:**

**CONTROL OF DC MOTORS**

Introduction to Thyristor controlled Drives, Single Phase semi and fully controlled converters connected to DC separately excited and DC series motors – continuous current operation – output voltage and current waveforms – Speed and Torque expressions – Speed – Torque Characteristics- Problems on Converter fed DCmotors.

Three phase semi and fully controlled converters connected to DCseparately excited and DCseries motors – output voltage and current waveforms – Speed and Torque expressions – Speed – Torque characteristics – Problems.

**UNIT-II:**

**FOUR QUADRANT OPERATION OF DC DRIVES**

Introduction to Four quadrant operation – Motoring operations, Electric Braking – Plugging, Dynamic, and Regenerative Braking operations. Four quadrant operation of D.C motors by single phase and three phase dual converters – Closed loop operation of DC motor (Block Diagram Only)

**CONTROL OF DC MOTORS BY CHOPPERS:** Single quadrant, two quadrant and four quadrant chopper fed dc separately excited and series motors – Continuous current operation – Output voltage and current wave forms – Speed and torque expressions – speed-torque characteristics – Problems on Chopper fed D.C Motors – Closed Loop operation (Block Diagram Only)

**UNIT-III:**

**CONTROL OF INDUCTION MOTOR**

Variable voltage characteristics-Control of Induction Motor by Ac Voltage Controllers – Waveforms – speed torque characteristics.

Variable frequency characteristics-Variable frequency control of induction motor by Voltage source and current source inverter and cyclo-converters- PWM control – Comparison of VSI and CSI operations – Speed torque characteristics – numerical problems on induction motor drives – Closed loop operation of induction motor drives (Block Diagram Only)

**UNIT-IV:**

**ROTOR SIDE CONTROL OF INDUCTION MOTOR**

Static rotor resistance control – Slip power recovery – Static Scherbius drive – Static Kramer Drive – their performance and speed torque characteristics – advantages, applications, problems.

**UNIT-V:**

**CONTROL OF SYNCHRONOUS MOTORS**

Separate control and self-control of synchronous motors – Operation of self-controlled synchronous motors by VSI, CSI and Cyclo-converters. Load commutated CSI fed Synchronous Motor – Operation – Waveforms – speed torque characteristics – Applications – Advantages and Numerical Problems – Closed Loop control operation of synchronous motor drives (Block Diagram Only), variable frequency control – Cyclo-converter, PWM based VSI& CSI.

**TEXT BOOKS:**

1. “G K Dubey”, Fundamentals of Electric Drives, CRC Press, 2002.
2. “VedamSubramanyam”, Thyristor Control of Electric drives, Tata McGraw Hill Publications, 1987.

**REFERENCES:**

1. “S K Pillai”, A First course on Electrical Drives, New Age International (P) Ltd. 2nd Edition. 1989
2. “P. C. Sen”, Thyristor DC Drives, Wiley-Blackwell, 1981
3. “B. K. Bose”, Modern Power Electronics, and AC Drives, Pearson 2015.
4. “R. Krishnan”, Electric motor drives - modelling, Analysis and control, Prentice Hall PTR, 2001

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**POWER QUALITY**

**(Professional Elective-II.3)**

**Prerequisite:** Power Systems and Power Electronics

**Course Objectives:**

* To know different terms of power quality.
* To illustrate power quality issues for short and long interruptions.
* To construct study of characterization of voltage sag magnitude and three phaseunbalanced voltage sag.
* To know the behavior of power electronics loads, induction motors, synchronousmotor etc. by the power quality issues
* To know mitigation of power quality problems by using VSI converters.

**Course Outcomes:** Upon the completion of this course, the student will be able to

* Know the severity of power quality problems in distribution system;
* Understand the concept of voltage sag transformation from up-stream (highervoltages) to down-stream (lower voltage)
* Compute the power quality improvement by using various mitigating custom power devices.

**UNIT-I:**

**INTRODUCTION**

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 powerquality, power quality monitoring.

**UNIT-II:**

**LONG & SHORT INTERRUPTIONS**

Interruptions – Definition – Difference between failures, outage, Interruptions – causes ofLong Interruptions – Origin of Interruptions – Limits for the Interruption frequency –Limits for the interruption duration – costs of Interruption – Overview of Reliabilityevaluation 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 ofshort interruptions, difference between medium and low voltage systems. Multipleevents, single phase tripping – voltage and current during fault period, voltage andcurrent at post fault period, stochastic prediction of short interruptions.

**UNIT III:**

**SINGLE-PHASE & THREE-PHASE VOLTAGE SAGCHARACTERIZATION**

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

**UNIT-IV:**

**POWER QUALITY CONSIDERATIONS IN INDUSTRIAL POWERSYSTEMS**

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

**UNIT-V:**

**MITIGATION OF INTERRUPTIONS & VOLTAGE SAGS**

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

**Power Quality and EMC Standards:**Introduction to standardization, IEC Electromagnetic compatibility standards, Europeanvoltage characteristics standards, PQ surveys.

**TEXT BOOKS:**

* 1. Math H J Bollen “Understanding Power Quality Problems”, IEEE Press.
	2. R.C. Dugan, M.F. McGranaghan and H.W. Beaty, “Electric Power Systems Quality.” New York: McGraw-Hill.1996

**REFERENCES:**

* 1. G.T. Heydt, ‘Electric Power Quality’, 2nd Edition. (West Lafayette, IN, Stars in a Circle Publications, 1994).
	2. Power Quality VAR Compensation in Power Systems, R. Sastry Vedam Mulukutla S.Sarma,CRC Press.
	3. A Ghosh, G. Ledwich, Power Quality Enhancement Using Custom Power Devices. Kluwer Academic, 2002.

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###### BUSINESS ECONOMICS AND FINANCIAL ANALYSIS

**Course Objectives:**

* To prepare engineering students to analyze cost/ revenue/ financial data
* To make economic and financial analysis in decision making process
* To examine the performance of companies engaged in engineering.

**Course Outcomes:** At the end of this course, students will demonstrate the ability to

* Perform and evaluate present and future worth of the alternate projects
* Appraise projects by using traditional and DCF Methods.
* Carry out cost benefit analysis of projects
* Calculate BEP of different alternative projects.

**UNIT-I:**

**INTRODUCTION TO ENGINEERING ECONOMICS:** Basic Principles and Methodology of Engineering Economics– Fundamental Concepts - Demand – Demand Determinants - Law of Demand- Demand Forecasting and Methods - Elasticity of Demand - Theory of Firm – Supply- Elasticity of Supply.

**UNIT-II:**

**MACRO ECONOMIC CONCEPTS:** National Income Accounting - Methods of Estimation- Various Concepts of National Income - Inflation – Definition – Causes of Inflation and Measures to Control Inflation - New Economic Policy 1991 (Industrial policy, Trade policy, and Fiscal policy) Impact on Industry.

**UNIT-III:**

**PRODUCTION, COST, MARKET STRUCTURES & PRICING:**Production Analysis: Factors of Production, Production Function, Production Function with one variable input, two variable inputs, Returns to Scale, Different Types of Production Functions. Cost analysis: Types of Costs, Short run and long run Cost Functions. Market Structures: Nature of Competition, Features of Perfect competition, Monopoly, Oligopoly, and Monopolistic Competition. Pricing: Types of Pricing, Product Life Cycle based Pricing, Break Even Analysis, Cost Volume Profit Analysis.

**UNIT-IV:**

**CAPITAL BUDGETING TECHNIQUES:** Significance of Capital Budgeting-cash flows-Time Value of Money- Choosing between alternative investment proposals- Methods of Appraisal Techniques- Pay Back Period - Average Rate of Return – Net Present Value- Internal Rate of Return – Profitability Index.

**UNIT-V:**

**INTRODUCTION TO ACCOUNTING:** Accounting Principles (GAPP), concepts, conventions- - Double entry system of Book keeping – Accounting rules- Journal- ledger- Trial balance- Trading and Profit and Loss account- Balance Sheet. (Simple Problems).

**TEXT BOOKS:**

* + - 1. Henry Malcom Steinar-Engineering Economics, Principles, McGraw Hill Pub.
			2. D.D. Chaturvedi, S.L.Gupta, Business Economics - Theory and Applications, International Book House Pvt. Ltd. 2013.

**REFERENCES:**

1. Jain and Narang” Accounting, Kalyani Publishers.
2. Arora, M.N.” Cost Accounting, Vikas Publication.
3. S.N.Maheshwari, Financial Management, Vikas Publishing House.

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 **3 0 0 3**

**POWER ELECTRONIC APPLICATIONS TO POWER SYSTEMS**

**Prerequisite:**Power System, Power Electronics

**CourseObjectives:**

* Understand the basics of formation of bus admittance matrix, modeling of transmission line, and analyze the load flow.
* Teach the analysis of sensitivity and the basics of power system security.
* Explain the voltage stability, proximity indicators and participation factors.
* Familiarize with FACT systems for controlling the power and configuration of various FACT devices.
* Introduce the thyristor-controlled series capacitor, its analysis, different modes of operation and various models.

**CourseOutcomes:** Aftercompletionofthecourse,studentswillbeableto:

* Create the bus admittance matrix, describe the reactive power of transmission line, model the transmission line, define the model of OLTC and analyze the load flow of lines.
* Analyze the sensitivity of different distribution factors, explain the power system security, and select and evaluate the contingency.
* Determine the voltage stability, proximity indicators and participation factor based on model analysis.
* Describe the FACT’s controllers for power system and configure various FACT devices.

**UNIT-I:**

Power System components models formation of bus admittance matrix, algorithm for formation of bus impedance matrix, Reactive power capability of an alternator, transmission line model and loadability, Reactive power transmission and associated difficulties, regulated shunt compensation, Models of OLTC and Phase shifting transformer, load flow study.

**UNIT-II:**

Sensitivity analysis: Generation shift distribution factors, line outage distribution factors, Compensated shift factors. Power system security levels, contingency selection and evaluation, security constrained economic dispatch. Pre-contingency corrective rescheduling.

**UNIT-III:**

Voltage stability: Proximity indicators e.g., slope of PV-curve, Minimum Eigen value of reduced load flow Jacobian, participation factors based on modal analysis and application.

**UNIT-IV:**

Flexible ac transmission systems, Reactive power control, Brief description and definition of FACT’s controllers, Shunt compensators, Configuration and operating characteristics of TCR, FC-TCR, TSC, Comparison of SVCs.

**UNIT-V:**

The Thyristor-controlled series capacitor (TCSC), Advantages of the TCSC, Basic principle and different mode of operation, Analysis, Variable-reactance model and transient stability model of TCSC.

**TEXTBOOKS:**

1. D. P. Kothari and I. J. Nagrath, “Modern Power System Analysis”, Tata McGraw Hill 2011.
2. A. J. Wood and B. F. Wollenberg, “Power generation, operation and control”, second edition John Wiley and Sons 1996.
3. N. G. Hingorani and L. Gyugyi, “Understanding facts: Concepts and Technology of flexible AC transmission systems”, Wiley Press 2000.

**REFERENCES:**

1. P. Kundur, “Power System Stability and control”, McGraw-Hill edition 2008.
2. R. M. Mathur and R. K. Varma, “Thyristor Based FACTS Controllers for electrical Transmission systems”, John Wiley and sons 2002.

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 **3 1 0 4**

**POWER SYSTEM PROTECTION**

**Pre-requisites:** Power Systems-I, Power Systems-II

**Course Objectives:**

* To introduce all kinds of circuit breakers and relays for protection of Generators, Transformers and feeder bus bars from Over voltages and other hazards.
* To describe neutral grounding for overall protection.
* To understand the phenomenon of Over Voltages and its classification.

**Course Outcomes:** At the end of the course the student will be able to:

* Compare and contrast electromagnetic, static and microprocessor-based relays
* Apply technology to protect power system components.
* Select relay settings of over current and distance relays.
* Analyze quenching mechanisms used in air, oil and vacuum circuit breakers

**UNTI-I:**

**PROTECTIVE RELAYS**

Introduction, Need for power system protection, effects of faults, evolution of protective relays, zones of protection, primary and backup protection, essential qualities of protection, classification of protective relays and schemes, current transformers, potential transformers, basic relay terminology.

**OPERATING PRINCIPLES AND RELAY CONSTRUCTION:** Electromagnetic relays, thermal relays, static relays, microprocessor based protective relays.

**UNTI-II:**

**OVER-CURRENT PROTECTION**

Time-current characteristics, current setting, over current protective schemes, directional relay, protection of parallel feeders, protection of ring mains, Phase fault and earth fault protection, Combined earth fault and phase fault protective scheme, Directional earth fault relay.

**DISTANCE PROTECTION:** Impedance relay, reactance relay, MHO relay, input quantities for various types of distance relays, Effect of arc resistance, Effect of power swings, effect of line length and source impedance on the performance of distance relays, selection of distance relays, MHO relay with blinders, Reduction of measuring units, switched distance schemes, auto re-closing.

**UNTI-III:**

**PILOT RELAYING SCHEMES**

Wire Pilot protection, Carrier current protection.

**AC MACHINES AND BUS ZONE PROTECTION:** Protection of Generators, Protection of transformers, Bus-zone protection, frame leakage protection.

**UNTI-IV:**

**STATIC RELAYS**

Amplitude and Phase comparators, Duality between AC and PC, Static amplitude comparator, integrating and instantaneous comparators, static phase comparators, coincidence type of phase comparator, static over current relays, static directional relay, static differential relay, static distance relays, Multi input comparators, concept of Quadrilateral and Elliptical relay characteristics.

**MICROPROCESSOR BASED RELAYS**: Advantages, over current relays, directional relays, distance relays.

**UNTI-V:**

**CIRCUIT BREAKERS**

Introduction, arcing in circuit breakers, arc interruption theories, re-striking and recovery voltage, resistance switching, current chopping, interruption of capacitive current, oil circuit breaker, air blast circuit breakers, SF6 circuit breaker, operating mechanism, selection of circuit breakers, high voltage DCbreakers, ratings of circuit breakers, testing of circuit breakers.

**FUSES:**Introduction, fuse characteristics, types of fuses, application of HRC fuses, discrimination.

**TEXT BOOKS:**

1. Badriram and D.N. Vishwakarma, Power System Protection and Switchgear, TMH 2001.
2. U.A.Bakshi, M.V.Bakshi: Switchgear and Protection, Technical Publications, 2009.

**REFERENCES:**

1. C.Russel Mason – “The art and science of protective relaying, Wiley Eastern, 1995
2. L.P.Singh “Protective relaying from Electromechanical to Microprocessors”, New Age International

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 **3 0 0 3**

**POWER SYSTEM OPERATION AND CONTROL**

**Pre-requisites:** Power System-I, Power System-II

**Course Objectives:**

* To understand real power control and operation
* To know the importance of frequency control
* To analyse different methods to control reactive power
* To understand unit commitment problem and importance of economic load dispatch
* To understand real time control of power systems

**Course Outcomes:** At the end of the course the student will be able to:

* Understand operation and control of power systems.
* Analyze various functions of Energy Management System (EMS) functions.
* Analyze whether the machine is in stable or unstable position.
* Understand power system deregulation and restructuring

**UNIT-I:**

**LOAD FLOW STUDIES**

Introduction, Bus classification -Nodal admittance matrix - Load flow equations - Iterative methods - Gauss and Gauss Seidel Methods, Newton-Raphson Method-Fast Decoupled Method-Merits and demerits of the above methods-System data for load flow study

**UNIT-II:**

**ECONOMIC OPERATION OF POWER SYSTEMS**

Distribution of load between units within a plant-Transmission loss as a function of plant generation, Calculation of loss coefficients-Distribution of load between plants.

**UNIT-III:**

**PF CONTROL**

Introduction, load frequency problem-Megawatt frequency (or P-f) control channel, MVAR voltages (or Q-V) control channel-Dynamic interaction between P-f and Q-V loops. Mathematical model of speed-governing system-Turbine models, division of power system into control areas, P-f control of single control area (the uncontrolled and controlled cases)-P-f control of two area systems (the uncontrolled cases and controlled cases)

**UNIT-IV:**

**POWER SYSTEM STABILITY**

The stability problem-Steady state stability, transient stability and Dynamic Stability-Swing equation. Equal area criterion of stability-Applications of Equal area criterion, Step by step solution of swing equation-Factors affecting transient stability, Methods to improve steady state and Transient stability, Introduction to voltage stability

**UNIT-V:**

**COMPUTER CONTROL OF POWER SYSTEMS**

Need of computer control of power systems. Concept of energy control centre (or) load dispatch centre and the functions - system monitoring - data acquisition and control. System hardware configuration – SCADA and EMS functions. Network topology – Importance of Load Forecasting and simple techniques of forecasting.

**TEXT BOOKS:**

1. C.L.Wadhwa, Electrical Power Systems, 3rd Edn, New Age International Publishing Co., 2001.
2. D.P.Kothari and I.J.Nagrath, Modern Power System Analysis, 4th Edn, Tata McGraw Hill Education Private Limited 2011.

**REFERENCES:**

1. D. P. Kothari: Modern Power System Analysis-Tata Mc Graw Hill Pub. Co. 2003.
2. Hadi Sadat: Power System Analysis –Tata Mc Graw Hill Pub. Co. 2002.

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###### POWER SYSTEM LAB

**Prerequisite:** Power System-I, PowerSystem-II, Power System Protection, Power System Operation and Control, Electrical Machines

**Course Objectives:**

* perform testing of CT, PT's and Insulator strings
* To find sequence impedances of 3-Φ synchronous machine and Transformer
* To perform fault analysis on Transmission line models and Generators.

**Course Outcomes:** After completion of this lab, the student will be able to

* Perform various load flow techniques
* Understand Different protection methods
* Analyse the experimental data and draw the conclusions**.**

**The following experiments are required to be conducted as compulsory experiments:**

**Part - A**

* 1. Characteristics of IDMT Over-Current Relay.
	2. Differential protection of 1-Φ transformer.
	3. Characteristics of Micro Processor based Over Voltage/Under Voltage relay.
	4. A, B, C, D constants of a Long Transmission line
	5. Finding the sequence impedances of 3-Φ synchronous machine.
	6. Finding the sequence impedances of 3-Φ Transformer.

**In addition to the above six experiments, at least any four of the experiments from the following list are required to be conducted.**

**Part - B**

1. Formation of YBUS.
2. Load Flow Analysis using Gauss Seidel (GS) Method.
3. Load Flow Analysis using Fast Decoupled (FD) Method.
4. Formation of ZBUS.
5. Simulation of Compensated Line

**TEXT BOOKS:**

1. C.L. Wadhwa: Electrical Power Systems –Third Edition, New Age International Pub. Co., 2001.
2. Hadi Sadat: Power System Analysis –Tata Mc Graw Hill Pub. Co. 2002.

**REFERENCES:**

1. D. P. Kothari: Modern Power System Analysis-Tata Mc Graw Hill Pub. Co. 2003.

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###### ELECTRICAL SIMULATION LAB

**Prerequisite**: Basic Electrical Engineering, Electrical Circuit Analysis, Control Systems, Power Electronics, Measurements and Instrumentation

**Course Objectives:**

* To develop the simulation skills.
* To generate various signals and synthesis for the engineering systems.
* To analyze harmonics in the systems.
* To analyze electrical circuit in simulation environment.

**Course Outcomes:** After going through this lab the student will be able to

* Apply signal generation in different systems.
* Analyze networks by various techniques
* Analyze circuit responses
* Analyze bridge rectifiers
* Analyze control systems problems
* Analyze basic converters and inverters

**The following experiments are required to be conducted compulsory experiments:**

1. Basic Operations on Matrices
2. Generation of various signals and sequences (Periodic and Aperiodic), such as unit Impulse, Step, Square, Saw tooth, Triangular, Sinusoidal, Ramp, Sinc.
3. Operations on signals and sequences such as Addition, Multiplication, Scaling, Shifting, Folding, Computation of Energy, and Average Power
4. Mesh and Nodal Analysis of Electrical circuits
5. Application of Network Theorems to Electrical Networks
6. Waveform Synthesis using Laplace Transform
7. Locating the Zeros and Poles and Plotting the Pole-Zero maps in S plane and Z-Plane for the given transfer function
8. Harmonic analysis of non-sinusoidal waveforms

**In addition to the above eight experiments, at least any two of the experiments from the following list are required to be conducted.**

1. Simulation of DC Circuits
2. Transient Analysis
3. Measurement of active Power of three phase circuit for balanced and unbalanced load
4. Simulation of single-phase diode bridge rectifiers with filter for R & RL load
5. Simulation of three phase diode bridge rectifiers with R, RL load
6. Design of Low Pass and High Pass filters
7. Finding the Even and Odd parts of Signal / Sequence and Real and imaginary parts of Signal
8. Finding the Fourier Transform of a given signal and plotting its magnitude and phase spectrum
9. Design of first and second order circuits in time and frequency domain
10. Design and analysis of feedback control systems
11. Design of Single-Phase Inverters
12. Design of Single-Phase Converters

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**POWER ELECTRONIC APPLICATIONS LAB**

Modeling and Simulation of the following experiments using MATLAB/Any other Simulation Software.

1. Closed loop Control of DC Motor.
2. Closed loop Control of Induction Motor.
3. Closed loop Control of Permanent Magnet Synchronous Motor.
4. Isolated Solar Photovoltaic Systems.
5. Grid Integrated Solar Photovoltaic Systems.
6. Isolated Wind Energy Conversion Systems.
7. Grid Integrated Wind Energy Conversion Systems.
8. Thyristor Controlled Reactor (TCR) for Reactive Power Compensation.
9. Fixed Capacitor Thyristor Controlled Reactor (FC-TCR) for Reactive Power Compensation.
10. Static Compensator (STATCOM) for Shunt Compensation.
11. Thyristor Controlled Switched Capacitor (TCSC) for Series Compensation.
12. High Voltage DC Transmission (HVDC) Model.

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**INTRODUCTION TO ARTIFICIAL INTELLIGENCE**

**(Mandatory Course)**

**Pre-requisites:** None

**Course Objectives:**

* To understand different types of AI agents, various AI search algorithms, fundamentals of knowledge representation, building of simple knowledge-based systems.
* To apply knowledge representation, reasoning. Study of Markov Models enable the student ready to step into applied AI.

**Course Outcomes:** At the end of the course the student will be able to:

* Classify basic search strategies for application to AI problems.
* Use probabilistic reasoning for search trees.
* Correlate the domain knowledge for learning and decision process.

**UNIT-I:**

**Introduction:** AI problems, Agents and Environments, Structure of Agents, Problem Solving Agents

**Basic Search Strategies**: Problem Spaces, Uninformed Search (Breadth-First, Depth-First Search,Depth-first with Iterative Deepening), Heuristic Search (Hill Climbing, Generic Best-First, A\*), ConstraintSatisfaction (Backtracking, Local Search).

**UNIT-II:**

**Advanced Search**: Constructing Search Trees, Stochastic Search, A\* Search Implementation,Minimax Search, Alpha-Beta Pruning

**Basic Knowledge Representation and Reasoning**: Propositional Logic, First-Order Logic, ForwardChaining and Backward Chaining, Introduction to Probabilistic Reasoning, Bayes Theorem.

**UNIT-III:**

**Advanced Knowledge Representation and Reasoning**: Knowledge Representation Issues, NonmonotonicReasoning, Other Knowledge Representation Schemes.

**Reasoning Under Uncertainty**: Basic probability, Acting Under Uncertainty, Bayes’ Rule,Representing Knowledge in an Uncertain Domain, Bayesian Networks.

**UNIT-IV:**

**Learning:** What Is Learning? Rote Learning, Learning by Taking Advice, Learning in Problem Solving,Learning from Examples, Winston’s Learning Program, Decision Trees.

**UNIT-V:**

**Expert Systems:** Representing and Using Domain Knowledge, Shell, Explanation, KnowledgeAcquisition.

**TEXT BOOKS:**

* 1. Russell, S. and Norvig, P, Artificial Intelligence: A Modern Approach, Third Edition, Prentice-Hall, 2010.
	2. Artificial Intelligence, Elaine Rich, Kevin Knight, Shivasankar B. Nair, The McGraw Hill publications, Third Edition, 2009.

**REFERENCE BOOKS:**

* + 1. George F. Luger, Artificial Intelligence: Structures and Strategies for Complex Problem Solving, Pearson Education, 6th ed., 2009.
		2. [www.techopedia.com](http://www.techopedia.com)
		3. www.classcentral.com