ACADEMIC REGULATIONS
COURSE STRUCTURE AND
DETAILED SYLLABUS

ELECTRICAL & ELECTRONICS ENGINEERING

For

M. Tech. (Electrical Power Engineering)

(Two Year **Full Time** Programme)

JNTUH COLLEGE OF ENGINEERING HYDERABAD
(Autonomous)
Kukatpally, Hyderabad – 500 085, Telangana, India.

2015

JNTUH COLLEGE OF ENGINEERING HYDERABAD

M.Tech. (Electrical Power Engineering) – Full Time w.e.f. 2015-16

I – SEMESTER

S.No.	Subject	L	T	P	Credits
1	Advanced Power System Analysis	4	0	0	4
2	Power System Operation and Deregulation	4	0	0	4
3	Elective-I	4	0	0	4
4	Elective-II	4	0	0	4
5	Elective-III	4	0	0	4
6	Elective-IV	4	0	0	4
7	Power System Simulation Lab	0	0	4	2
8	General Seminar	0	0	4	2
	Total Credits				**28**

II – SEMESTER

S.No.	Subject	L	T	P	Credits
1	Advanced Power System Protection	4	0	0	4
2	Power System Dynamics	4	0	0	4
3	Elective-V	4	0	0	4
4	Elective-VI	4	0	0	4
5	Elective-VII	4	0	0	4
6	Elective-VIII	4	0	0	4
7	Power Systems Lab	0	0	4	2
8	Technical Seminar	0	0	4	2
	Total Credits				**28**

III – SEMESTER

S.No.	Subject	L	T	P	Credits
1	Comprehensive Viva Voce				4
2	Project Phase –I				12
	Total Credits				**16**

IV – SEMESTER

S.No.	Subject	L	T	P	Credits
	Project Phase-II & Dissertation				18
	Total credits				**18**

Elective-I
1. High Voltage Engineering
2. Reactive Power Compensation and Management
3. High Frequency Magnetic Components

Elective-II
1. Analysis of HVDC Systems
2. Renewable Energy Systems
3. Voltage Stability

Elective-III
1. Modern Control Theory
2. Advanced Digital Signal Processing
3. Industrial Instrumentation

Elective-IV
1. Microcontrollers and Applications
2. Embedded Systems
3. Reliability Engineering
4. Optimization Techniques
5. Energy Generation from Waste
6. Integration of Energy Sources

Elective-V
1. EHV AC Transmission
2. Gas Insulated Systems
3. Smart Grid Technologies

Elective-VI
1. Flexible AC Transmission Systems
2. Power System Reliability
3. Digital Control Systems

Elective-VII
1. Power Quality
2. Solar Photo Voltaic Systems
3. Distribution Automation

Elective-VIII
1. Programmable Logic Controllers and Applications
2. AI Techniques in Electrical Engineering
3. Energy Efficient Systems
4. Software Engineering
5. Energy Storage Technologies
6. Electrical Engineering Materials

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L	T	P	C
4	0	0	4

ADVANCED POWER SYSTEM ANALYSIS
(Core Theory - 1)

Prerequisite: Computer Methods in Power Systems

Course Objectives:
- To analyze a Power System Network using graph theory.
- To interpret the formation of Network matrices.
- To understand the necessity of load flow studies and various methods of Analysis.
- To examine short circuit analysis using Z_{Bus}.

Course Outcomes:
Upon the completion of this course, the student will be able to
- Develop various models of power system for analysis.
- Obtain load flows of power systems
- Apply contingency Analysis.
- Analyze power systems under various faults.

UNIT-I:
Admittance Model and Network Calculations, Branch and Node Admittances, Mutually Coupled Branches in Y_{BUS} , An Equivalent Admittance Network, Modification of Y_{BUS} , Network Incidence Matrix and Y_{BUS} , Method of Successive Elimination, Node Elimination, Triangular Factorization, Sparsity and Near Optimal Ordering.

UNIT-II:
Impedance Model and Network Calculations, the BUS Admittance and Impedance Matrices, Thevenin's Theorem and Z_{BUS} ,Algorithms for building Z_{BUS} Modification of existing $Z_{BUS,}$ Calculation of Z_{BUS} elements from $Y_{BUS,}$ Power Invariant Transformations, Mutually Coupled Branches in $Z_{BUS.}$

UNIT-III:
Gauss Seidel method, N-R Method, Decoupled method, fast decoupled method, comparison between power flow solutions. DC load flow.

UNIT-IV:
Z_{BUS} Method in Contingency Analysis, Adding and Removing Multiple Lines, Piecewise Solution of Interconnected Systems, Analysis of Single Contingencies, Analysis of Multiple Contingencies, Contingency Analysis of DC Model, System Reduction for Contingency and Fault Studies.

UNIT-V:
Fault Analysis: Symmetrical faults-Fault calculations using Z_{BUS} - Fault calculations using Z_{BUS} equivalent circuits – Selection of circuit breakers- Unsymmetrical faults - Problems on various types of faults.

TEXT BOOKS:

1. John J. Grainger and W.D. Stevenson, "Power System Analysis"- T.M.H.Edition.
2. Modern Power System Analysis – by I.J.Nagrath & D.P.Kothari Tata M Graw – Hill Publishing Company Ltd, 2nd edition.

REFERENCES:

1. Power System Analysis and Design by J. Duncan Glover and M.S.Sarma, Cengage 3rd Edition.
2. Olle L.Elgard, "Electrical Energy Systems Theory" - T.M.H.Edition.
3. Power systems stability and control, Prabha Kundur, The McGraw Hill companies**.**
4. Power System Operation and Control, Dr. K. Uma Rao, Wiley India Pvt. Ltd.
5. Operation and Control in Power Systems, PSR Murthy, Bs Publications.
6. Power System Operation, Robert H. Miller, Jamesh H. Malinowski, Tata McGraw Hill publisher**.**
7. Power Systems Analysis, operation and control by Abhijit Chakrabarti, Sunitha Halder, PHI 3rd Edition, 2010.

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L	T	P	C
4	0	0	4

POWER SYSTEM OPERATION AND DEREGULATION
(Core Theory - 2)

Prerequisite: Power System Operation and Control

Course objectives:
- To emphasize Optimal Power Flow with security constraints.
- To explain system security through contingency analysis.
- To demonstrate the different stages and means of state estimation of power system.
- To apply the concept of deregulation and ATC.

Course Outcomes:
Upon the completion of this course, the student will be able to
- Model the optimal power flow considering different security constraints.
- Evaluate the N-1 contingencies for system security analysis.
- Perform Power system state estimation and their stages.
- Understand the power system deregulation and ATC calculations.

UNIT- I: OPTIMAL POWER FLOW
Introduction- Solution to the optimal power flow-gradient method-Newton's method-Linear sensitivity analysis- Linear programming methods- Security constrained OPF-Interior point algorithm- Bus incremental costs

UNIT-II: POWER SYSTEM SECURITY
Introduction –Factors affecting power system security-Contingency analysis-Detection of network problems-Linear sensitivity analysis-AC power flow methods-contingency selection-concentric relaxation-Bounding area method

UNIT-III: STATE ESTIMATION IN POWER SYSTEMS
Introduction - Power system state estimation - Maximum likelihood Weighted Least squares estimation - Matrix formulation - State estimation of AC network - State estimation by orthogonal decomposition - detection and identification of Bad measurements - Estimation of quantities not being measured - Network observability and pseudo measurements.

UNIT-IV: POWER SYSTEM DEREGULATION
Introduction - motivation for restructuring of power systems - Electricity market entities model-benefits of deregulation - terminology-deregulation in Indian power sector - Operations in power markets - power pools - transmission networks and electricity markets.

UNIT-V: AVAILABLE TRANSFER CAPABILITY
Introduction methods: of determination of ATC - ATC calculation considering the effect of contingency analysis- Transmission open access and pricing-cost components of transmission system- transmission pricing methods-Incremental cost based transmission pricing.

TEXT BOOKS:

1. A.J.Wood & B.F.Woollenberg- John Wiley “Power Generation, Operation and Control”- 2nd edition.
2. P.Venkatesh, B.V.Manikandan, S.Charles Raja- A.Srinivasan, “Electrical power systems: Analysis, security, Deregulation”– PHI 2012

REFERENCES:

1. Bhattacharya, Kankar, Bollen, Math, Daalder, Jaap E. “Operation of Restructured Power System”, 2001, Springer.
2. Venkatesh P., Manikandan B. V., Raja S. Charles, Srinivasan A. Electrical Power Systems: Analysis, Security And Deregulation, PhI Learning Pvt. Ltd.

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ELECTIVE – 1.1: HIGH VOLTAGE ENGINEERING

Prerequisite: Power Systems and Electrical & Electronics Instrumentation

Course Objectives:

- To distinguish the Gaseous, liquid and solid dielectric behavior under High Voltages.
- To understand the generation methods of High A.C, DC & Impulse Voltages required for various application.
- To apply the measuring techniques of High AC, DC & Impulse voltages and currents.
- To identify the testing techniques for High Voltage Equipment.

Course Outcomes:

Upon the completion of this course, the student will be able to

- Know conduction and breakdown in gases, liquids and solids dielectrics and different applications of the insulating materials in electrical power apparatus.
- Know the insulation testing of various components in power systems for different voltages, viz. power frequency, high frequency, switching or lightning impulses.
- Interpret the necessity to measure the voltages and currents accurately, ensuring perfect safety to the personnel and equipment.
- Obtain the necessary condition for all the electrical equipment capable of withstanding the over voltages.
- Knowledge of protection of electrical equipments against high voltages.

UNIT- I: INTRODUCTION TO HIGH VOLATGE ENGINEERING

Electric Field Stresses, Gas / Vacuum as Insulator, Liquid Dielectrics, Solids and Composites, Estimation and Control of Electric Stress, Numerical methods for electric field computation, Surge voltages and their distribution and control, Applications of insulating materials in transformers, rotating machines, circuit breakers, cable power capacitors and bushings.

UNIT- II: BREAK DOWN IN DIELECTRIC MATERIALS

Gases as insulating media, collision process, Ionization process, Townsend's criteria of breakdown in gases, Paschen's law. Liquid as Insulator, pure and commercial liquids, breakdown in pure and commercial liquids. Intrinsic breakdown, electromechanical breakdown, thermal breakdown, breakdown of solid dielectrics in practice, Breakdown in composite dielectrics, solid dielectrics used in practice.

UNIT-III: GENERATION & MEASUREMENT OF HIGH VOLTAGES & CURRENTS

Generation of High Direct Current Voltages, Generation of High alternating voltages, Generation of Impulse Voltages, Generation of Impulse currents, Tripping and control of impulse generators. Measurement of High Direct Current voltages, Measurement of High Voltages alternating and impulse, Measurement of High Currents-direct, alternating and Impulse, Oscilloscope for impulse voltage and current measurements.

UNIT-IV: OVER VOLTAGES & INSULATION CO-ORDINATION

Natural causes for over voltages – Lightning phenomenon, Overvoltage due to switching surges, system faults and other abnormal conditions, Principles of Insulation Coordination on High voltage and Extra High Voltage power systems.

UNIT- V: TESTING OF MATERIALS & ELECTRICAL APPARATUS

Measurement of D.C Resistivity, Measurement of Dielectric Constant and loss factor, Partial discharge measurements. Testing of Insulators and bushings, Testing of Isolators and circuit breakers, testing of cables, Testing of Transformers, Testing of Surge Arresters, and Radio Interference measurements.

TEXT BOOKS:

1. High Voltage Engineering by M.S.Naidu and V. Kamaraju – TMH Publications, 3rd Edition.
2. High Voltage Engineering: Fundamentals by E.Kuffel, W.S.Zaengl, J.Kuffel by Elsevier, 2nd Edition.

REFERENCES:

1. High Voltage Engineering by C.L.Wadhwa, New Age Internationals (P) Limited, 1997.
2. High Voltage Insulation Engineering by Ravindra Arora, Wolfgang Mosch, New Age International (P) Limited, 1995.
3. High Voltage Engineering, Theory and Practice by Mazen Abdel Salam, Hussein Anis, Ahdan El-Morshedy, Roshdy Radwan , Marcel Dekker

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4	0	0	4

ELECTIVE – 1.2: REACTIVE POWER COMPENSATION AND MANAGEMENT

Prerequisite: Power Systems

Course Objectives:

- To identify the necessity of reactive power compensation
- To describe load compensation
- To select various types of reactive power compensation in transmission systems
- To illustrate reactive power coordination system
- To characterize distribution side and utility side reactive power management.

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

- Distinguish the importance of load compensation in symmetrical as well as un symmetrical loads
- Observe various compensation methods in transmission lines
- Construct model for reactive power coordination
- Distinguish demand side reactive power management & user side reactive power management

UNIT-I: LOAD COMPENSATION
Objectives and specifications – reactive power characteristics – inductive and capacitive approximate biasing – Load compensator as a voltage regulator – phase balancing and power factor correction of unsymmetrical loads- examples.

UNIT-II: STEADY–STATE REACTIVE POWER COMPENSATION IN TRANSMISSION SYSTEM
Uncompensated line – types of compensation – Passive shunt and series and dynamic shunt compensation – examples.

TRANSIENT STATE REACTIVE POWER COMPENSATION IN TRANSMISSION SYSTEMS:
Characteristic time periods – passive shunt compensation – static compensations - series capacitor compensation – compensation using synchronous condensers – examples

UNIT-III: REACTIVE POWER COORDINATION
Objective – Mathematical modeling – Operation planning – transmission benefits – Basic concepts of quality of power supply – disturbances- steady –state variations – effects of under voltages – frequency –Harmonics, radio frequency and electromagnetic interferences

UNIT-IV: DEMAND SIDE MANAGEMENT
Load patterns – basic methods load shaping – power tariffs- KVAR based tariffs penalties for voltage flickers and Harmonic voltage levels

DISTRIBUTION SIDE REACTIVE POWER MANAGEMENT:
System losses –loss reduction methods – examples – Reactive power planning – objectives – Economics Planning capacitor placement – retrofitting of capacitor banks

UNIT-V: USER SIDE REACTIVE POWER MANAGEMENT
KVAR requirements for domestic appliances – Purpose of using capacitors – selection of capacitors – deciding factors – types of available capacitor, characteristics and Limitations
Reactive power management in electric traction systems and arc furnaces:
Typical layout of traction systems – reactive power control requirements – distribution transformers- Electric arc furnaces – basic operations- furnaces transformer –filter requirements – remedial measures –power factor of an arc furnace

TEXT BOOKS:
1. Reactive power control in Electric power systems by T.J.E.Miller, John Wiley and sons, 1982.
2. Reactive power Management by D.M.Tagare, Tata McGraw Hill, 2004.

REFERENCES:
1. Wolfgang Hofmann, Jurgen Schlabbach, Wolfgang Just “Reactive Power Compensation: A Practical Guide, April, 2012, Wiley publication.

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ELECTIVE – 1.3: HIGH FREQUENCY MAGNETIC COMPONENTS

Prerequisite: POWER SYSTEMS

Course Objectives:
- To have a knowledge on magnetic circuits
- To know the skin effect and proximity effect
- To analyze the basics of transformer design for different topologies

Course Outcomes:
Upon the completion of this course, the student will be able to
- Design of magnetic components (i.e., inductor and transformer) in a converter.
- Perform steady-state analysis of switched mode power supply.
- Understand core loss in an electromagnetic device, recognize & describe its effect.
- Describe the engineering uses of electromagnetic waves, by frequency band, and the respective hazards associated with them

UNIT-I:
FUNDAMENTALS OF MAGNETIC DEVICES: Introduction, Magnetic Relationships, Magnetic Circuits, Magnetic Laws, Eddy Currents, Core Saturation, Volt-Second Balance, Inductance, Inductance Factor, Magnetic Energy, Self-Resonant Frequency, Classification of Power Losses in Magnetic Components, Non-inductive Coils.
MAGNETIC CORES: Introduction, Properties of Core Materials, Magnetic Dipoles, Magnetic Domains, Curie Temperature, Magnetization, Magnetic Materials, Hysteresis, Core Permeability, Core Geometries, Iron Alloy Cores, Amorphous Alloy Cores, Nickel–Iron and Cobalt–Iron Cores, Ferrite Cores, Powder Cores, Nano-crystalline Cores, Superconductors, Hysteresis Core Loss, Eddy-Current Core Loss, Total Core Loss, Complex Permeability.

UNIT-II:
SKIN EFFECT & PROXIMITY EFFECT: Introduction, Magnet Wire, Wire Insulation, Skin Depth, Ratio of AC-to-DC Winding Resistance, Skin Effect in Long Single Round Conductor, Current Density in Single Round Conductor, Impedance of Round Conductor, Magnetic Field Intensity for Round Wire, Other Methods of Determining the Round Wire Inductance, Power Density in Round Conductor, Skin Effect on Single Rectangular Plate. Proximity and Skin Effects in Two Parallel Plates, Anti-proximity and Skin Effects in Two Parallel Plates, Proximity Effect in Multiple-Layer Inductor, Appendix: Derivation of Proximity Power Loss.
WINDING RESISTANCE AT HIGH FREQUENCIES: Introduction, Winding Resistance, Square and Round Conductors, Winding Resistance of Rectangular Conductor, Winding Resistance of Square Wire, Winding Resistance of Round Wire, Leakage Inductance, Solution for Round Conductor Winding in Cylindrical Coordinates, Litz Wire, Winding Power Loss for Inductor Current with Harmonics, Effective Winding Resistance for Non-sinusoidal Inductor Current, Thermal Model of Inductors.

UNIT-III:
TRANSFORMERS: Introduction, Neumann's Formula for Mutual Inductance, Mutual Inductance, Energy Stored in Coupled Inductors, Magnetizing Inductance, Leakage Inductance, Measurement of Transformer Inductances, Stray Capacitance, High-Frequency

Transformer Model, Non-interleaved Windings, Interleaved Windings, AC Current Transformers, Winding Power Losses with Harmonics, Thermal Model of Transformers.
DESIGN OF TRANSFORMERS: Introduction, Area Product Method, Optimum Flux Density, Transformer Design for Fly-back Converter in CCM, Transformer Design for Fly-back Converter in DCM, Transformer Design for Fly-back Converter in CCM, Transformer Design for Fly-back Converter in DCM.

UNIT-IV:
INTEGRATED INDUCTORS: Introduction, Resistance of Rectangular Trace, Inductance of Straight Rectangular Trace, Construction of Integrated Inductors, Meander Inductors, Inductance of Straight Round Conductor, Inductance of Circular Round Wire Loop, Inductance of Two-Parallel Wire Loop, Inductance of Rectangle of Round Wire, Inductance of Polygon Round Wire Loop, Bond-wire Inductors, Single-Turn Planar Inductor, Inductance of Planar Square Loop, Planar Spiral Inductors, Multi-metal Spiral Inductors, Planar Transformers, MEMS Inductors, Inductance of Coaxial Cable, Inductance of Two-Wire Transmission Line, Eddy Currents in Integrated Inductors, Model of RF Integrated Inductors, PCB Inductors.
DESIGN OF INDUCTORS: Introduction, Restrictions on Inductors, Window Utilization Factor, Temperature Rise of Inductors, Mean Turn Length of Inductors, Area Product Method, AC Inductor Design, Inductor Design for Buck Converter in CCM, Inductor Design for Buck Converter in DCM method.

UNIT-V:
SELF-CAPACITANCE: Introduction, High-Frequency Inductor Model, Self-Capacitance Components, Capacitance of Parallel-Plate Capacitor, Self-Capacitance of Foil Winding Inductors, Capacitance of Two Parallel Round Conductors, Capacitance of Round Conductor and Conducting Plane, Self-Capacitance of Single-Layer Inductors, Self-Capacitance of Multi-layer Inductors, Capacitance of Coaxial Cable.

TEXT BOOKS:
1. Design of Magnetic Components for Switched Mode Power Converters, Umanand L., Bhat,S.R., ISBN:978-81-224-0339-8, Wiley Eastern Publication, 1992.

REFERENCES:
1. High-Frequency Magnetic Components, Marian K. Kazimierczuk, ISBN: 978-0-470-71453-9 John Wiley & Sons, Inc.
2. G.C. Chryssis, High frequency switching power supplies, McGraw Hill, 1989 (2nd Edn.)
3. Eric Lowdon, Practical Transformer Design Handbook, Howard W. Sams & Co., Inc., 1980
4. “Thompson --- Electrodynamic Magnetic Suspension.pdf”
5. Witulski --- “Introduction to modeling of transformers and coupled inductors” Beattie --- “Inductance 101.pdf”
6. P. L. Dowell, "Effects of eddy currents in transformer windings.pdf"
7. Dixon--- “Eddy current losses in transformer windings.pdf”
8. J J Ding, J S Buckkeridge, “Design Considerations For A Sustainable Hybrid Energy System” IPENZ Transactions, 2000, Vol. 27, No. 1/EMCh.
9. Texas Instruments --- “Windings.pdf”
10. Texas Instruments --- “Magnetic core characteristics.pdf” Ferroxcube --- “3f3 ferrite datasheet.pdf” Ferroxcube --- “Ferrite selection guide.pdf” Magnetics, Inc., Ferrite Cores (www.mag-inc.com).

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ELECTIVE – 2.1: ANALYSIS OF HVDC SYSTEMS

Prerequisite: Power Electronics and Power Systems

Course Objectives:

- To Comprehend the conversion principles of HVDC Transmission
- Analysis of 3, 6, 12 pulse converters, rectifier and inverter operations of HVDC converters
- To identify the different types of Harmonics and its suppression methods including Filters
- To comprehend the requirement of grounding and grounding electrodes for HVDC systems.

Course Outcomes:

Upon the completion of this course, the student will be able to

- Find the applications of HVDC transmission in the power system with the acquired knowledge.
- Analyze different converter topologies viz. 3, 6 and 12 Pulse converters and understand it's control aspects.
- Understand the filter configuration and harmonic suppression methods.
- Have knowledge on grounding electrodes and their design for HVDC systems.

UNIT-I

INTRODUCTION: General consideration, Power Handling Capabilities of HVDC Lines Basic Conversion principles, static converter configuration.

STATIC POWER CONVERTERS: 3-pulse, 6-pulse, and 12-pulse converters, converter station and Terminal equipment, commutation process, Rectifier and inverter operation, equivalent circuit for converter – special features of converter transformers

UNIT-II

CONTROL OF HVDC CONVERTERS AND SYSTEMS: Introduction – Mechanism of AC power transmission – principles of control – necessity of control in case of a DC link – Rectifier control – compounding of rectifiers – power reversal in a DC link – VDCOL Characteristics of converter – System control hierarchy – Inverter extinction angle control – pulse phase control – starting and stopping of a DC link – constant power control – control systems for HVDC converters inverter operation problems control of VSC converters.

UNIT-III

HARMONICS IN HVDC SYSTEMS: Introduction – Generation of harmonics by converters – Characteristic harmonics on DC side – Characteristic Current harmonics – Characteristic variation of Harmonic currents – Effect of control modes on harmonics – Non-characteristic harmonics – Harmonics in VSC converters.

UNIT-IV

HARMONIC SUPPRESSION IN HVDC SYSTEMS – FILTERS: Introduction – Harmonic model and Equivalent circuit – use of filters – filter configuration – design of band-pass filter – minimum cost of tuned AC filters – design of high-pass filters – protection of filters –

Reactive power considerations – DC filters – Power line communication and RI noise – Active filters and their applications – Filters with VSC HVDC schemes – other methods of harmonic elimination.

UNIT-V

GROUNDING AND GROUNDING ELECTRODES FOR HVDC SYSTEMS: Introduction – Advantages and problems with ground return – HVDC systems grounding – The current field in earth near an electrode – Resistance of electrodes-electric current field –Distribution of current field between the electrodes – natural current field due to the Earth's magnetic field – Effect of ground return on buried objects – requirements of electrodes – basic parameters of design of ground electrodes – design of land electrodes.

TEXT BOOKS:

1. E.W. Kimbark: Direct current Transmission, Wiely Inter Science – New York.
2. HVDC Transmission by S. Kamakshaiah, V. Kamaraju, Tata McGraw Hill Education Private Limited.
3. J. Arillaga HVDC Transmission Peter Peregrinus Ltd. London UK 1983.

REFERENCE BOOKS:

1. K. R. Padiyar, "High Voltage Direct current Transmission", Wiley Eastern Ltd New Delhi – 1992.
2. E. Uhlman, "Power Transmission by Direct Current", Springer Verlag, Berlin Helberg. 1985.

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4	0	0	4

ELECTIVE – 2.2: RENEWABLE ENERGY SYSTEMS

Prerequisite: None

Course Objectives:

- To create the awareness of energy conservation in students
- To identify renewable energy sources for electrical power generation
- To analyze different energy storage methods
- To have knowledge on environmental effects of energy conversion

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

- Find different renewable energy sources to produce electrical power
- Estimate conventional energy sources to produce electrical energy
- Role-play the fact that the conventional energy resources are depleted
- Arrange Stored energy and to avoid the environmental pollution

UNIT- I: SOLAR ENERGY SYSTEMS:
Introduction – solar radiation - solar thermal energy conversion - Flat plate collector - concentric collectors- solar pond - central receiver system- solar pumping - Solar photovoltaic systems - characteristics of PV cell- Photo voltaic modules - Types of Photo voltaic systems.

UNIT-II: WIND ENERGY AND BIO GAS:
Basics of wind energy - classification of turbines - wind characteristics - energy extraction - Betz limit - Modes of wind power generation- Bio Mass energy conversion - Anaerobic Digestion - Aerobic Digestion - Gasification-Bio Gas Plants.

UNIT-III: OCEAN ENERGY CONVERSION:
Tidal Energy generation - characteristics of Tides - Power generation schemes - Components in Tidal power plant- Wave Energy - Principle of wave energy plant - Wave energy conversion machines - Ocean Thermal Energy conversion - Principle - cycles of operation - Types of OTEC plants - Applications

UNIT-IV: GEO-THERMAL ENERGY AND FUEL CELLS:
HYBRID ENERGY SYSTEMS:
Geothermal Energy - Structure of Earth's interior - Geothermal fields, gradient, resources - Geothermal power generation - Fuel cells – Introduction - Principle of operation - Types of **FUEL CELLS** - State of art fuel cells-energy output of a fuel cell - operating characteristics of fuel cells - thermal efficiency - Need for Hybrid systems - Types of Hybrid systems.

UNIT-V: ENVIRONMENTAL ASPECTS OF ELECTRIC ENERGY GENERATION:
Introduction - Thermal pollution - Hydel power projects - Impact on environment - Nuclear power generation – Impact on environment - Impact of renewable energy generation on environment - Global environmental awareness.

TEXT BOOKS:

1. D.P.Kothari, K.C.Singal, R.Ranjan, ”Renewable Energy Resources and emerging technologies”- PHI 2/e 2011.
2. John Twidell and Tony Weir ,“Renewable Energy Resources” - 2nd edition, CRC Press.
3. Rakosh Das Begamudre, “Energy conversion systems”- New Age International Publishers, New Delhi - 2000.
4. “Energy conversion systems” by Rakosh das Begamudre, New age International publishers, New Delhi - 2000.
5. “Renewable Energy Resources” by John Twidell and Tony Weir, 2nd Edition, Fspon & Co.

REFERENCES:

1. “Understanding Renewable Energy Systems”, by Volker Quaschning, 2005, UK.
2. “Renewable Energy Systems-Advanced Conversion, Technologies & Applications” by Faner Lin Luo Honer Ye, CRC press, Taylor & Francis group.

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L	T	P	C
4	0	0	4

ELECTIVE – 2.3: VOLTAGE STABILITY

Prerequisite: Computers Methods in Power Systems

Course Objectives:
- To illustrate voltage stability phenomenon.
- To identify the role of load modeling in voltage stability studies.
- To estimate the different voltage stability indices and stability margins.

Course Outcomes:
Upon the completion of this course, the student will be able to
- Understand issues related to power system stability and control.
- Demonstrate various load models in voltage stability analysis.
- know reactive power compensation techniques & their practical importance

UNIT–I: INTRODUCTION TO VOLTAGE STABILITY
Definitions: Voltage Stability, Voltage Collapse, Voltage Security; Physical relation indicating dependency of voltage on reactive power flow; Factors affecting Voltage collapse and instability; Previous cases of voltage collapse incidences.

UNIT–II: GRAPHICAL ANALYSIS OF VOLTAGE STABILITY
Comparison of Voltage and angular stability of the system; Graphical Methods describing voltage collapse phenomenon: P-V and Q-V curves; detailed description of voltage collapse phenomenon with the help of Q-V curves.

UNIT–III: ANALYSIS OF VOLTAGE STABILITY
Analysis of voltage stability on SMIB system: Analytical treatment and analysis.
Voltage Stability Indices:
Voltage collapse proximity indicator - Determinant of Jacobin as proximity indicators - Voltage stability margin.

UNIT–IV: POWER SYSTEM LOADS
Loads that influences voltage stability: Discharge lights, Induction Motor, Air-conditioning, heat pumps, electronic power supplies, OH lines and cables.
Reactive Power Compensation:
Generation and Absorption of reactive power; Series and Shunt compensation; Synchronous condensers, SVC's, OLTC's and Booster Transformers.

UNIT–V: VOLTAGE STABILITY MARGIN
Stability Margin: Compensated and un-compensated systems.
Voltage Security: Definition - Voltage security - Methods to improve voltage stability and its practical aspects.

TEXT BOOKS:
1. "Performance, operation and control of EHV power transmission system"- A.CHAKRABARTHY, D.P.KOTARI and A.K.MUKOPADYAY, A.H.Wheeler Publishing, I Edition, 1995.
2. "Power System Dynamics: Stability and Control" – K.R.PADIYAR, II Edition, B.S. Publications.

REFERENCES:
1. "Power System Voltage Stability"- C.W.TAYLOR, McGraw Hill, 1994

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ELECTIVE – 3.1: MODERN CONTROL THEORY

Prerequisite: Control Systems

Course Objectives:

- To explain the concepts of basics and modern control system for the real time analysis and design of control systems.
- To explain the concepts of state variables analysis.
- To study and analyze non linear systems.
- To analyze the concept of stability for nonlinear systems and their categorization.
- To apply the comprehensive knowledge of optimal theory for Control Systems.

Course Outcomes:

Upon completion of this course, students should be able to:

- Various terms of basic and modern control system for the real time analysis and design of control systems.
- To perform state variables analysis for any real time system.
- Apply the concept of optimal control to any system.
- Able to examine a system for its stability, controllability and observability.
- Implement basic principles and techniques in designing linear control systems.
- Formulate and solve deterministic optimal control problems in terms of performance indices.
- Apply knowledge of control theory for practical implementations in engineering and network analysis.

UNIT I: MATHEMATICAL PRELIMINARIES AND STATE VARIABLE ANALYSIS:

Fields, Vectors and Vector Spaces – Linear combinations and Bases – Linear Transformations and Matrices – Scalar Product and Norms – Eigen values, Eigen Vectors and a Canonical form representation of Linear systems – The concept of state – State space model of Dynamic systems – Time invariance and Linearity – Non uniqueness of state model – State diagrams for Continuous-Time State models - Existence and Uniqueness of Solutions to Continuous-Time State Equations – Solutions of Linear Time Invariant Continuous-Time State Equations – State transition matrix and it's properties. Complete solution of state space model due to zero input and due to zero state.

UNIT II: CONTROLLABILITY AND OBSERVABILITY:

General concept of controllability – Controllability tests, different state transformations such as diagonalization, Jordon canonical forms and Controllability canonical forms for Continuous-Time Invariant Systems – General concept of Observability – Observability tests for Continuous-Time Invariant Systems – Observability of different State transformation forms.

UNIT III: STATE FEEDBACK CONTROLLERS AND OBSERVERS:

State feedback controller design through Pole Assignment, using Ackkermans formula– State observers: Full order and Reduced order observers.

UNIT IV: NON-LINEAR SYSTEMS:

Introduction – Non Linear Systems - Types of Non-Linearities – Saturation – Dead-Zone - Backlash – Jump Phenomenon etc; Linearization of nonlinear systems, Singular Points and its types– Describing function–describing function of different types of nonlinear elements, – Stability analysis of Non-Linear systems through describing functions. Introduction to phase-plane analysis, Method of Isoclines for Constructing Trajectories, Stability analysis of nonlinear systems based on phase-plane method.

UNIT V: STABILITY ANALYSIS:
Stability in the sense of Lyapunov, Lyapunov's stability and Lypanov's instability theorems - Stability Analysis of the Linear continuous time invariant systems by Lyapunov second method – Generation of Lyapunov functions – Variable gradient method – Krasoviski's method.

TEXT BOOKS:
1. M.Gopal, Modern Control System Theory, New Age International - 1984
2. Ogata. K, Modern Control Engineering, Prentice Hall - 1997
3. N K Sinha, Control Systems, New Age International – 3rd edition.

REFERENCES:
1. Donald E.Kirk, Optimal Control Theory an Introduction, Prentice - Hall Network series - First edition.

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ELECTIVE – 3.2: ADVANCED DIGITAL SIGNAL PROCESSING

Prerequisite: Digital signal processing

Objectives:

- To emphasize the advanced concepts of digital signal processing and the mathematical basis of discrete time signal analysis.
- To introduce the implementation of DSP algorithms and power spectrum analysis.

Outcomes:

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

- Solve the various types of practical problems of DSP processors.
- Develop DSP based real time systems.
- Design and analyze various filters.

UNIT–I:

DIGITAL FILTER STRUCTURES: Block diagram representation – Equivalent Structures – FIR and IIR digital filter Structures AII pass Filters - tunable IIR Digital Sine-cosine generator - Computational complexity of digital filter structures.

UNIT-II:

DIGITAL FILTER DESIGN: Preliminary considerations- Bilinear transformation method of IIR filter design –design of Low pass high pass – Band pass, and Band stop- IIR digital filters – Spectral transformations of IIR filters – FIR filter design – based on Windowed Fourier series – design of FIR digital filters with least – mean square-error – constrained Least – square design of FIR digital filters.

UNIT-III:

DSP ALGORITHM IMPLEMENTATION: Computation of the discrete Fourier transform- Number representation – Arithmetic operations – handling of overflow – Tunable digital filters – function approximation.

UNIT-IV:

ANALYSIS OF FINITE WORD LENGTH EFFECTS: The Quantization process and errors- Quantization of fixed –point and floating –point Numbers – Analysis of coefficient Quantization effects – Analysis of Arithmetic Round-off errors- Dynamic range scaling – signal –to- noise in Low –order IIR filters- Low – Sensitivity Digital filter – Reduction of Product round-off errors feedback – Limit cycles in IIR digital filter – Round – off errors in FFT Algorithms.

UNIT-V:

POWER SPECTRUM ESTIMATION: Estimation of spectra from Finite Duration Observations signals- Non-parametric methods for power spectrum Estimation- parametric method for power spectrum Estimation- Estimation of spectral form-Finite duration observation of signals- Non-parametric methods for power spectrum estimation – Walsh methods – Blackman and torchy method.

TEXT BOOKS:

1. Sanjit K. Mitra, Digital signal processing – TMH second edition
2. Alan V. Oppenheim, Ronald W, Shafer, Discrete Time Signal Processing – PHI 1996 1st Edition reprint
3. John G. Proakis, Digital Signal Processing principles – Algorithms and Applications – PHI – 3rd edition 2002.

REFERENCES:

1. S Salivahanan. A. Vallavaraj C. Gnanapriya, Digital Signal Processing – TMH – 2nd reprint 2001.
2. Lourens R Rebinarand Bernold, Theory and Applications of Digital Signal Processing.
3. Auntoniam, Digital Filter Analysis and Design, TMH.

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ELECTIVE – 3.3: INDUSTRIAL INSTRUMENTATION

Prerequisite: None

Objectives:

- To study the characteristics of instruments
- Analyze the various type s of transducers
- Principle of operation and selection of transducers depend s on their applications.
- Basic knowledge of displacement, strain, pressure, temperature, flow, level, density, and viscosity measurements.

Outcomes:

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

- Select the transducers and their types, usage and operation and different characteristics of transducers.
- Calibrate the various instruments and application of various instruments to different fields.
- Implement process techniques, instrumental setups as well as controlling and monitoring of various processes in the industries.

UNIT – I: INTRODUCTION:

Introduction to Instrumentation system - Static and Dynamic characteristics of Instruments - Principles of transducers.

UNIT- II: MEASUREMENT OF DISPLACEMENT & STRAIN:

Displacement and proximity gauges - Linear Variable Differential Transformer (LVDT) - Measurement of strain: Strain Gauge - unbalanced Wheatstone bridge.

UNIT – III: MEASUREMENT OF TEMPERATURE:

Thermocouples - Resistance Temperature Detector (RTD) - Thermisters and radiation pyrometer.

UNIT- IV : MEASUREMENT OF FLOW:

Measurement of level: Capacitance based and Float based method.Differential pressure flow meters - variable area flow meters- variable reluctance flow meters - Turbine flow meter - Ultrasonic flow meter (Both transit time and Doppler Shift) - Electromagnetic flow meter and mass flow meter.

UNIT – V: MEASUREMENT OF PRESSURE & OTHER QUANTITIES:

Elastic transducers- Low pressure measurement-McLeod and ionization gauge-Load cell - Torque Cell - pH probe and viscosity measurement - Basics of Data transmission - Synchro and Servo motor - Pneumatic and Hydraulic Instrumentation system.

TEXT BOOK:

1. E. Doeblin,” Industrial Instrumentation”- CRC Press
2. A.K.Sawhney, Course in Electrical and Electronics Measurements and Instrumentation, Dhanpat Rai & Company

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ELECTIVE-4.1: MICROCONTROLLERS AND APPLICATIONS

Prerequisite: Microprocessors and Interfacing Devices

Course Objectives:

- To relate the basic architecture and addressing modes of a microcontroller.
- To explain the principles of top down design to microcontroller software development
- To demonstrate assembly language programs for the advanced Microcontroller , assembly language code for high-level language structures such as IF-THEN-ELSE and DO-WHILE
- To analyze a typical I/O interface and to discuss timing issues
- To identify different types of memories used in microcontrollers

Course Outcomes:

Upon the completion of this course, the student will be able to

- Distinguish types of computers & microcontrollers,
- Use 8-Bit, 16- Bit & 32 Bit advanced Microcontrollers.
- Develop Real time Applications of Microcontrollers & Demonstrate RTOS for Microcontrollers.
- Translate Hardware applications using Microcontrollers.

UNIT-I: OVERVIEW OF ARCHITECTURE & MICROCONTROLLER RESOURCES

Architecture of a microcontroller – Microcontroller resources – Resources in advanced and next generation microcontrollers – 8051 microcontroller – Internal and External memories – Counters and Timers – Synchronous serial-cum asynchronous serial communication - Interrupts.

UNIT-II: 8051- MICROCONTROLLERS INSTRUCTION SET

Basic assembly language programming – Data transfer instructions – Data and Bit-manipulation instructions – Arithmetic instructions – Instructions for Logical operations on the test among the Registers, Internal RAM, and SFRs – Program flow control instructions – Interrupt control flow.

UNIT-III: REAL TIME CONTROL

INTERRUPTS: Interrupt handling structure of an MCU – Interrupt Latency and Interrupt deadline – Multiple sources of the interrupts – Non-maskable interrupt sources – Enabling or disabling of the sources – Polling to determine the interrupt source and assignment of the priorities among them – Interrupt structure in Intel 8051.

TIMERS: Programmable Timers in the MCU's – Free running counter and real time control – Interrupt interval and density constraints.

UNIT-IV: SYSTEMS DESIGN

DIGITAL AND ANALOG INTERFACING METHODS: Switch, Keypad and Keyboard interfacings – LED and Array of LEDs – Keyboard-cum-Display controller (8279) – Alphanumeric Devices – Display Systems and its interfaces – Printer interfaces – Programmable instruments interface using IEEE 488 Bus – Interfacing with the Flash Memory – Interfaces – Interfacing to High Power Devices – Analog input interfacing –

Analog output interfacing – Optical motor shaft encoders – Industrial control – Industrial process control system – Prototype MCU based Measuring instruments – Robotics and Embedded control – Digital Signal Processing and digital filters.

UNIT-V: REAL TIME OPERATING SYSTEM FOR MICROCONTROLLERS:
Real Time operating system – RTOS of Keil (RTX51) – Use of RTOS in Design – Software development tools for Microcontrollers.

16-BIT MICROCONTROLLERS: Hardware – Memory map in Intel 80196 family MCU system – IO ports – Programmable Timers and High-speed outputs and input captures – Interrupts – instructions.
ARM 32 Bit MCUs: Introduction to 16/32 Bit processors – ARM architecture and organization – ARM / Thumb programming model – ARM / Thumb instruction set – Development tools.

TEXT BOOKS:
1. Raj Kamal, "Microcontrollers Architecture, Programming, Interfacing and System Design" – Pearson Education, 2005.
2. Mazidi and Mazidi, "The 8051 Microcontroller and Embedded Systems" – PHI, 2000.

REFERENCES:
1. A.V. Deshmuk, "Microcontrollers (Theory & Applications)" – WTMH, 2005.
2. John B. Peatman, "Design with PIC Microcontrollers" – Pearson Education, 2005.
3. Microcontroller Programming, Julio Sanchez, Maria P. Canton, CRC Press.
4. The 8051 Microcontroller, Ayala, Cengage Learning.
5. Microprocessors and Microcontrollers, Architecture, Programming and System Design, Krishna Kant, PHI Learning PVT. Ltd.
6. Microprocessors, Nilesh B. Bahadure, PHI Learning PVT. Ltd.

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ELECTIVE-4.2: EMBEDDED SYSTEMS

Prerequisite: Microprocessors and Interfacing Devices

Course Objectives:
- To emphasize the general embedded system concepts, design of embedded hardware and software development tools
- To explain the basics of real time operating and embedded systems
- To describe key issues such as CPU scheduling, memory management, task synchronization, and file system in the context of real-time embedded systems.

Course Outcomes:
Upon the completion of this course, the student will be able to
- To analyze and design embedded systems and real-time systems
- Define the unique design problems and challenges of real-time systems
- Identify the unique characteristics of real-time operating systems and evaluate the need for real-time operating system
- Explain the general structure of a real-time system and Understand and use RTOS to build an embedded real-time system
- Gain knowledge and skills necessary to design and develop embedded applications based on real-time operating systems.

UNIT- I: OVERVIEW OF EMBEDDED SYSTEM
Embedded System, types of Embedded System, Requirements of Embedded System, and Issues in Embedded software development, Applications.

UNIT-II: PROCESSOR & MEMORY ORGANIZATION
Structural units in a processor, Processor selection, Memory devices, Memory selection, Memory Allocation & Map, Interfacing.

UNIT-III: DEVICES, DEVICE DRIVERS & BUSES FOR DEVICE NETWORKS
I/O devices, Timer & Counter devices, Serial Communication, Communication between devices using different buses. Device drives, Parallel and serial port device drives in a system, Interrupt servicing mechanism, context and periods for context switching, Deadline and Interrupt Latency.

UNIT-IV: PROGRAMMING & MODELING CONCEPTS
Program elements, Modeling Processes for Software Analysis, Programming Models, Modeling of Multiprocessor Systems, Software algorithm Concepts, design, implementation, testing, validating, debugging, Management and maintenance, Necessity of RTOS.

UNIT-V: HARDWARE AND SOFTWARE CO-DESIGN
Embedded system design and co-design issues in software development, design cycle in development phase for Embedded System, Use of ICE & Software tools for development of ES, Issues in embedded system design.

TEXTBOOKS:

1. Embedded systems: Architecture, programming and design by Rajkamal, TMH
2. Embedded system design by Arnold S Burger, CMP

REFERENCES:

1. An embedded software primer by David Simon, PEA
2. Embedded systems design:Real world design be Steve Heath; Butterworth Heinenann, Newton mass USA 2002
3. Data communication by Hayt.

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ELECTIVE-4.3: RELIABILITY ENGINEERING

Prerequisite: None

Course Objectives:

- To comprehend the concept of Reliability and Unreliability
- Derive the expressions for probability of failure, Expected value and standard deviation of Binominal distribution, Poisson distribution, normal distribution and weibull distributions.
- Formulating expressions for Reliability analysis of series-parallel and Non-series parallel systems
- Deriving expressions for Time dependent and Limiting State Probabilities using Markov models.

Course Outcomes:

Upon the completion of this course, the student will be able to

- Apply fundamental knowledge of Reliability to modeling and analysis of series-parallel and Non-series parallel systems.
- Solve some practical problems related
- Understand or become aware of various failures, causes of failures and remedies for failures in practical systems.

UNIT I:

Rules for combining probabilities of events, Definition of Reliability. Significance of the terms appearing in the definition. Probability distributions: Random variables, probability density and distribution functions. Mathematical expectation, Binominal distribution, Poisson distribution, normal distribution, weibull distribution.

UNIT II:

Hazard rate, derivation of the reliability function in terms of the hazard rate. Failures: Causes of failures, types of failures (early failures, chance failures and wear-out failures). Bath tub curve. Preventive and corrective maintenance. Modes of failure. Measures of reliability: mean time to failure and mean time between failures.

UNIT III:

Classification of engineering systems: series, parallel and series-parallel systems-Expressions for the reliability of the basic configurations.

Reliability evaluation of Non-series-parallel configurations: Decomposition, Path based and cutest based methods, Deduction of the Paths and cut-sets from Event tree.

UNIT IV:

Discrete Markov Chains: General modeling concepts, stochastic transitional probability matrix, time dependent probability evaluation and limiting state probability evaluation of one component repairable model. Absorbing states.

Continuous Markov Processes: Modeling concepts, State space diagrams, Stochastic Transitional Probability Matrix, Evaluating time dependent and limiting state Probabilities of one component repairable model. Evaluation of limiting state probabilities of two component repairable model.

UNIT-V:
Approximate system Reliability analysis of Series systems, parallel systems with two and more than two components, Network reduction techniques. Minimal cutest/failure mode approach.

TEXT BOOKS:
1. “Reliability evaluation of Engineering systems”, Roy Billinton and Ronald N Allan, BS Publications.
2. “Reliability Engineering”, Elsayed A. Elsayed, Prentice Hall Publications.

REFERENCES:
1. “Reliability Engineering: Theory and Practice”, By Alessandro Birolini, Springer Publications.
2. “An Introduction to Reliability and Maintainability Engineering”, Charles Ebeling, TMH Publications.
3. “Reliability Engineering”, E. Balaguruswamy, TMH Publications.

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ELECTIVE-4.4: OPTIMIZATION TECHNIQUES

Prerequisite: None

Course Objectives:

- To understand the theory of optimization methods and algorithms developed for solving various types of optimization problems.
- To develop an interest in applying optimization techniques in problems of Engineering and Technology
- To apply the mathematical results and numerical techniques of optimization theory to concrete Engineering problems.

Course Outcomes:

Upon the completion of this course, the student will be able to

- Know basic theoretical principles in optimization
- formulate optimization models and obtain solutions for optimization;
- apply methods of sensitivity analysis and analyze post processing of results

UNIT – I

INTRODUCTION AND CLASSICAL OPTIMIZATION TECHNIQUES:

Statement of an Optimization problem – design vector – design constraints – constraint surface – objective function – objective function surfaces – classification of Optimization problems.

CLASSICAL OPTIMIZATION TECHNIQUES

Single variable Optimization – multi variable Optimization without constraints – necessary and sufficient conditions for minimum/maximum – multivariable Optimization with equality constraints.

Solution by method of Lagrange multipliers – multivariable Optimization with inequality constraints – Kuhn – Tucker conditions.

UNIT – II

LINEAR PROGRAMMING

Standard form of a linear programming problem – geometry of linear programming problems – definitions and theorems – solution of a system of linear simultaneous equations – pivotal reduction of a general system of equations – motivation to the simplex method – simplex algorithm.

UNIT – III

TRANSPORTATION PROBLEM

Finding initial basic feasible solution by north – west corner rule, least cost method and Vogel's approximation method – testing for optimality of balanced transportation problems.

UNCONSTRAINED NONLINEAR PROGRAMMING:

One – dimensional minimization methods: Classification, Fibonacci method and Quadratic interpolation method

U**NIT – IV**

UNCONSTRAINED OPTIMIZATION TECHNIQUES

Univariate method, Powell's method and steepest descent method.

CONSTRAINED NONLINEAR PROGRAMMING:
Characteristics of a constrained problem, Classification, Basic approach of Penalty Function method; Basic approach of Penalty Function method; Basic approaches of Interior and Exterior penalty function methods. Introduction to convex Programming Problem.

UNIT – V
DYNAMIC PROGRAMMING:
Dynamic programming multistage decision processes – types – concept of sub optimization and the principle of optimality – computational procedure in dynamic programming – examples illustrating the calculus method of solution - examples illustrating the tabular method of solution.

TEXT BOOKS:
1. “Engineering optimization: Theory and practice”-by S. S.Rao, New Age International (P) Limited, 3rd edition, 1998.
2. “Introductory Operations Research” by H.S. Kasene & K.D. Kumar, Springer(India), Pvt .LTd.

REFERENCES:
1. “Optimization Methods in Operations Research and systems Analysis” – by K.V. Mital and C. Mohan, New Age International (P) Limited, Publishers, 3rd edition, 1996.
2. Operations Research – by Dr. S.D.Sharma.
3. “Operations Research: An Introduction” by H.A. Taha, PHI Pvt. Ltd., 6th edition
4. Linear Programming by G. Hadley

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ELECTIVE-4.5: ENERGY GENERATION FROM WASTE

Prerequisite: None

Course Objectives:
- To understand the theory of Nonconventional energy sources.
- To develop an interest in applying energy generation from waste and solve problems of Engineering and Technology.

Course Outcomes:
Upon the completion of this course, the student will be able to
- Apply fundamental knowledge of NCPG to Generate Energy from Waste.
- Solve some related practical problems**.**
- Understand or become aware of various failures, causes of failures and remedies for failures in practical systems

UNIT-I:
Solid Waste Sources Solid Waste Sources, types, composition, Properties, Global warming, Municipal Solid Waste: Physical, chemical and biological properties , Waste Collection and, Transfer stations, Waste minimization and recycling of municipal waste, Segregation of waste, Size Reduction , Managing Waste. Status of technologies for generation of Energy from Waste Treatment and Disposal Aerobic composting, incineration, Furnace type and design, Medical waste /Pharmaceutical waste treatment Technologies, incineration, Environmental impacts, Measures to mitigate environmental effects due to incineration .

UNIT-II:
Land Fill method of Solid waste disposal Land fill classification, Types, methods and Sitting consideration, Layout and preliminary design of landfills: Composition, characteristics, generation, Movement and control of landfill leach ate and gases, Environmental monitoring system for land fill gases.

UNIT-III:
Energy Generation from Waste Bio-chemical Conversion: Sources of energy generation, anaerobic digestion of sewage and municipal wastes, direct combustion of MSW-refuse derived solid fuel, Industrial waste, agro residues, Anaerobic Digestion.

UNIT-IV:
Biogas production, Land fill gas generation and utilization, Thermo-chemical conversion: Sources of energy generation, Gasification of waste using Gasifiers, Briquetting, Utilization and advantages of briquetting, Environmental benefits of Bio-chemical and Thermo-chemical conversion.

UNIT–V:
E-waste: e-waste in the global context – Growth of Electrical and Electronics Industry in India – Environmental concerns and health hazards – Recycling e-waste: a thriving economy of the unorganized sector – Global trade in hazardous waste – impact of hazardous e-waste in India. Management of e-waste: e-waste legislation, Government regulations on e-waste

management – International experience – need for stringent health safeguards and environmental protection laws of India.

TEXT BOOKS:

1. Nicholas P. Cheremisinoff. Handbook of Solid Waste Management and Waste Minimization Technologies. An Imprint of Elsevier, New Delhi (2003).
2. P. Aarne Vesilind, William A. Worrell and Debra R. Reinhart. Solid Waste Engineering. Thomson Asia Pte Ltd. Singapore (2002)
3. M. Dutta , B. P. Parida, B. K. Guha and T. R. Surkrishnan. Industrial Solid Waste Management and Landfilling practice. Narosa Publishing House, New Delhi (1999).
4. "E-waste in India: Research unit, Rajya Sabha Secretariat, New Delhi, June 2011"
5. Amalendu Bagchi. Design, construction and Monitoring of Landfills. John Wiley and Sons. New York. (1994)
6. M. L. Davis and D. A. Cornwell. Introduction to environmental engineering. Mc Graw Hill International Edition, Singapore (2008)
7. C. S. Rao. Environmental Pollution Control Engineering. Wiley Eastern Ltd. New Delhi (1995)
8. S. K. Agarwal. Industrial Environment Assessment and Strategy. APH Publishing Corporation. New Delhi (!996)
9. Sofer, Samir S. (ed.), Zaborsky, R. (ed.), "Biomass Conversion Processes for Energy and Fuels", New York, Plenum Press, 1981
10. Hagerty, D.Joseph; Pavoni, Joseph L; Heer, John E., "Solid Waste Management", New York, Van Nostrand, 1973
11. George Tchobanoglous, Hilary Theisen and Samuel Vigil Prsl: Tchobanoglous, George Theisen, Hillary Vigil, Samuel, "Integrated Solid Waste management: Engineering Principles and Management issues", New York, McGraw Hill, 1993.

REFERENCES:

1. C Parker and T Roberts (Ed), Energy from Waste - An Evaluation of Conversion Technologies, Elsevier Applied Science, London, 1985
2. KL Shah, Basics of Solid and Hazardous Waste Management Technology, Prentice Hall, 2000 3. M Datta, Waste Disposal in Engineered Landfills, Narosa Publishing House, 1997
3. G Rich et.al, Hazardous Waste Management Technology, Podvan Publishers, 1987
4. AD Bhide, BB Sundaresan, Solid Waste Management in Developing Countries, INSDOC, New Delhi,1983 FUEL CELL AND
5. **Google books:**
   (i) e-waste Management: From waste to Resource Klaus Hieronymi, Ramzy Kahnat, Eric williams Tech. & Engg.-2013(Publisher: Earthscan 2013).
   (ii) What is the impact of E-waste: Tamara Thompson
   (iii) E-waste poses a Health Hazard: Sairudeen Pattazhy
6. **Weblinks :**
   www.unep.org
   www.routledge.com
   www.amazon.com
   www.bookdepository.com
   www.ecoactiv.com

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ELECTIVE-4.6: INTEGRATION OF ENERGY SOURCES

Prerequisite: Power Systems

Course Objectives:
Upon successful completion of the course the students will be familiar with:

- To introduce the characteristics of various types of renewable energy sources and converters.
- To explain the importance of storage and sizing of hybrid systems.
- To introduce the control issues of isolated systems.
- To explain the harmonics, power quality, voltage imperfections, power injection issues on the grid by integrating renewable energy sources.

Course Outcomes:
At the end of the course, the student should be able to:

- Identify the characteristics of renewable energy sources and converters.
- Analyze the importance of storage and sizing of hybrid systems.
- Realize the problems related to isolated systems.
- Analyze the challenges faced by the grid by integrating renewable energy sources.

UNIT- I:
REVIEW OF CHARACTERISTICS OF POWER SOURCES: Basic review of power generation from wind - Solar PV - Thermal - Small hydro - Biomass power strategies in each of these energy conversion systems - Review of maximum power point tracking techniques in solar PV and wind (perturb & observe, hill climbs, incremental conductance).

UNIT-II:
CONVERTER TOPOLOGIES: DC/DC converter (buck, boost, buck boost) - DC/AC inverters (sine, triangular, PWM techniques) - Phase locked loop for inverters.

UNIT-III:
HYBRID SYSTEMS: Advantages of hybrid power systems - Importance of storage in hybrid power systems - Design of hybrid power system based on load curve - Sizing of hybrid power systems.

UNIT-IV:
ISOLATED SYSTEMS: Control issues in isolated systems for voltage and frequency - Small signal stability in isolated power systems - Importance of storage and dump load in isolated systems.

UNIT-V:
ISSUES IN INTEGRATION OF RENEWABLE ENERGY SOURCES: Overview of challenges in integrating renewable sources to the grid - Impact of harmonics on power quality - Need to maintain voltage within a band and fluctuations in voltage because of renewable integration - Power inverter and converter technologies - Mechanism to synchronize power from renewable sources to the grid - Overview of challenges faced in

designing power injection from offshore generation sources - Challenges in modeling intermittent nature of renewable power in a power system.

TEXT BOOKS:

1. Power Electronics, Converters, Applications and Design" by N. Mohan; T.M. Undeland; W.P. Robbins. 1995, John Wiley and Sons.
2. Renewable Energy Integration Challenges and Solutions Series: Green Energy and Technology Hossain, Jahangir,Mahmud, Apel (Eds.)
3. Integration of Alternative Sources of Energy Felix A. Farret, M. Godoy Simões, December 2005, Wiley-IEEE Press.

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POWER SYSTEM SIMULATION LAB

Course Objectives:

Upon successful completion of the lab students will be familiar with:

- Construction of Y-bus, z-bus for a n-bus system.
- Load flow studies methods.
- Steady state, transient stability analysis.
- Reliability analysis of generation and distribution
- Simulation studies of converters and drives used in power systems

Course Outcomes:
At the end of the course, the student should be able to:
- Construct Y-bus and Z-bus
- Compare the different load flow methods
- Analyze the different stability analysis of variety of power systems
- Calculate reliability indices for generation distribution
- Simulate basic electrical circuits
- Simulate power electronic converters and drives

1. Develop Program for Y_{BUS} formation.
2. Develop Program for G-S Load Flow Analysis.
3. Develop Program for N-R Load Flow Analysis.
4. Develop Program for FDLF Analysis.
5. Develop Program for Short Circuit Analysis.
6. Develop Program for Transient Stability Analysis for Single Machine connected to Infinite Bus by Point by Point Method.
7. Develop Program for Generation System Reliability Analysis.
8. Develop Program for Distribution System Reliability Analysis.
9. Develop Simulation of RLC Circuit
10. Develop Simulation of Single Phase Full Converter with RLE Load
11. Develop Program model for Closed Loop Speed Control of Separately Excited D.C Motor.
12. Develop Program model for Sinusoidal Pulse Width Modulation.

Note: From the above list minimum 10 experiments are to be conducted using suitable software.

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ADVANCED POWER SYSTEM PROTECTION
(Core Theory - 3)

Prerequisite: Switch Gear and Protection

Course Objectives:
- To have basic concepts of static relay and its design principles of amplitude and phase comparators.
- To illustrate the application of static relays in over current protection scheme, differential protection scheme and distance relaying schemes.
- To illustrate the problems with power swings and relay coordination and its mitigations.

Course Outcomes:
Upon the completion of this course, the student will be able to
- Understand the advantages of static relaying system and its basic components.
- Understand the implementation of static relay schemes for over current, differential and distance relaying schemes.
- Understand the operation and control of microprocessor based relays.

UNIT-I: STATIC RELAYS
Advantages of static relays-Basic construction of static relays-Level detectors - Replica impedance - Mixing circuits-General equation for two input phase and amplitude comparators-Duality between amplitude and phase comparators.
AMPLITUDE COMPARATORS: Circulating current type and opposed voltage type- rectifier bridge comparators, Direct and Instantaneous comparators.

UNIT-II: PHASE COMPARATORS
Coincidence circuit type- block spike phase comparator - techniques to measure the period of coincidence - Integrating type - Rectifier and Vector product type- Phase comparators.
STATIC OVER CURRENT RELAYS: Instantaneous over-current relay-Time over-current relays-basic principles - definite time and Inverse definite time over-current relays.

UNIT-III: STATIC DIFFERENTIAL RELAYS
Analysis of Static Differential Relays - Static Relay schemes - Duo bias transformer differential protection –Harmonic restraint relay.
STATIC DISTANCE RELAYS: Static impedance-reactance - MHO and angle impedance relay -sampling comparator - realization of reactance and MHO relay using sampling comparator.

UNIT-IV: MULTI-INPUT COMPARATORS
Conic section characteristics - Three input amplitude comparator - Hybrid comparator - switched distance schemes - Poly phase distance schemes - phase fault scheme - three phase scheme – combined and ground fault scheme.
POWER SWINGS: Effect of power swings on the performance of distance relays – Power swing analysis-Principle of out of step tripping and blocking relays-effect of line and length and source impedance on distance relays.

UNIT-V: MICROPROCESSOR BASED PROTECTIVE RELAYS (Block diagram and flowchart approach only): Over current relays–impedance relays-directional relay-reactance relay .Generalized mathematical expressions for distance relays-measurement of resistance and reactance –MHO and offset MHO relays-Realization of MHO characteristics -Realization of offset MHO characteristics -Basic principle of Digital computer relaying.

TEXT BOOKS:

1. Badri Ram and D. N. Vishwakarma, “Power system protection and Switch gear “, TMH publication New Delhi 1995.
2. T. S. Madhava Rao, “Static relays”, TMH publication, second edition 1989.

REFERENCES:

1. Protection and Switchgear, Bhavesh Bhalja, R. P. Maheshwari, Nileh G. Chothani, Oxford University Press.
2. Electrical Power System Protection, C. Christopoulos and A. Wright, Springer International.

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POWER SYSTEM DYNAMICS
(Core Theory - 4)

Prerequisite: Computer Methods in Power Systems

Course objectives:
- To make aware of modelling aspects of different power system elements.
- To analyse the dynamic performance of single machine connected to infinite power systems.
- To illustrate the system stability issues and requisite control strategies.

Course Outcomes:
Upon the completion of the subject, the student will be able to
- Choose the fundamental dynamic behavior and controls of power systems to perform basic stability analysis.
- Comprehend concepts in modeling and simulating the dynamic phenomena of power systems
- Interpret results of system stability studies
- Analyze theory and practice of modeling main power system components, such as synchronous machines, excitation systems and governors

UNIT-I: BASIC CONCEPTS
Power system stability states of operation and system security - system dynamics - problems system model analysis of steady State stability and transient stability - simplified representation of Excitation control.

UNIT-II: MODELING OF SYNCHRONOUS MACHINE
Synchronous machine - park's Transformation-analysis of steady state performance per - unit quantities-Equivalent circuits of synchronous machine-determination of parameters of equivalent circuits.

UNIT-III: EXCITATION SYSTEM
Excitation system modeling-excitation systems block Diagram - system representation by state equations- Dynamics of a synchronous generator connected to infinite bus - system model Synchronous machine model-stator equations rotor equations - Synchronous machine model with field circuit - one equivalent damper winding on q axis (model 1.1) - calculation of Initial conditions.

UNIT-IV: ANALYSIS OF SINGLE MACHINE SYSTEM
Small signal analysis with block diagram - Representation Characteristic equation and application of Routh Hurwitz criterion- synchronizing and damping torque analysis-small signal model - State equations.

UNIT-V: APPLICATION OF POWER SYSTEM STABILIZERS
Basic concepts in applying PSS - Control signals - Structure and tuning of PSS - Washout circuit - Dynamic compensator analysis of single machine infinite bus system with and without PSS.

TEXT BOOKS:

1. K.R. PADIYAR," Power system dynamics "- B.S. Publications.
2. P.M. Anderson and A.A. Fouad, "Power system control and stability", IEEE Press

REFERENCES:

1. R. Ramanujam, "Power Systems Dynamics"- PHI Publications.

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ELECTIVE – 5.1: EHV AC TRANSMISSION

Prerequisite: Power Systems

Course objectives:
- To identify the different aspects of Extra High Voltage A.C and DC Transmission design and analysis
- To understand the importance of modern developments of EHV and UHV transmission systems.
- To demonstrate EHV AC transmission system components, protection and insulation level for over voltages.

Course Outcomes:
Upon the completion of this course, the student will be able to
- Understand the importance of EHV AC transmission
- Estimate choice of voltage for transmission, line losses and power handling capability of EHV Transmission.
- Analyse by applying the statistical procedures for line designs, scientific and engineering principles in power systems.

UNIT- I:
E.H.V.A.C. Transmission line trends and preliminary aspect standard transmission voltages – Estimation at line and ground parameters-Bundle conductor systems-Inductance and Capacitance of E.H.V. lines – positive, negative and zero sequence impedance – Line Parameters for Modes of Propagation.

UNIT- II:
Electrostatic field and voltage gradients – calculations of electrostatic field of AC lines – effect of high electrostatic field on biological organisms and human beings - surface voltage gradients and maximum gradients of actual transmission lines – voltage gradients on sub conductor.

UNIT- III:
Electrostatic induction in unenergized lines – measurement of field and voltage gradients for three phase single and double circuit lines – unenergized lines. Power Frequency Voltage control and over-voltages in EHV lines: No load voltage – charging currents at power frequency-voltage control – shunt and series compensation – static VAR compensation.

UNIT - IV:
Corona in E.H.V. lines – Corona loss formulae- attention of traveling waves due to Corona – Audio noise due to Corona, its generation, characteristic and limits. Measurements of audio noise radio interference due to Corona - properties of radio noise – frequency spectrum of RI fields – Measurements of RI and RIV.

UNIT- V:
Design of EHV lines based on steady state and transient limits - EHV cables and their characteristics.

TEXT BOOKS:

1. R. D. Begamudre, “EHVAC Transmission Engineering”, New Age International (p) Ltd. 3rd Edition.
2. K.R. Padiyar, “HVDC Power Transmission Systems” New Age International (p) Ltd. 2nd revised Edition, 2012.

REFERENCES:

1. S. Rao “EHVAC and HVDC Transmission Engineering. Practice” Khanna publishers.
2. Arrillaga. J “High Voltage Direct Current Transmission” 2nd Edition (London) Peter Peregrines, IEE, 1998.
3. Padiyar.K.R, “FACTS Controllers in Power Transmission and Distribution” New Age International Publishers, 2007.
4. Hingorani H G and Gyugyi. L “Understanding FACTS-Concepts and Technology of Flexible AC Transmission Systems” New York, IEEE Press, 2000.

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ELECTIVE – 5.2: GAS INSULATED SYSTEMS

Prerequisite: Switch Gear and Protection

Course objectives:

- To know the GIS concepts and principles
- To distinguish Air Insulated and Gas insulated Substations
- To demonstrate the design and constructional aspects of GIS
- To analyze transient phenomenon, problems and diagnostic methods in GIS

Course Outcomes:

Upon the completion of this course, the student will be able to

- Know the advantages of GIS systems over air insulated systems
- Observe constructional design features of GIS design
- Discriminate the problems and design diagnostic methods of GIS

UNIT–I: INTRODUCTION TO GIS AND PROPERTIES OF SF_6

Characteristics of GIS- Introduction to SF_6 - Physical properties-Chemical properties - Electrical properties-Specification of SF_6 gas for GIS application - Handling of SF_6 gas before use - Safe handling of Sf_6 gas in electrical equipment - Equipment for handling the SF_6 Gas - SF_6 and environment.

UNIT–II: LAYOUT OF GIS STATIONS

Advancement of GIS station - Comparison with Air Insulated Substation - Economics of GIS - User Requirements for GIS - Main Features for GIS - Planning and Installation components of a GIS station.

UNIT–III: DESIGN AND CONSTRUCTION OF GIS STATION

Introduction - Rating of GIS components - Design Features - Estimation of different types of Electrical Stresses -Design Aspects of GIS components - Insulation Design for Components - Insulation Design for GIS - Thermal Considerations in the Design of GIS - Effect of very Fast Transient Over-voltages (VFTO) on the GIS design - Insulation Coordination systems - Gas handling and Monitoring System Design.

UNIT-IV: FAST TRANSIENT PHENOMENA IN GIS

Introduction - Disconnector Switching in Relation to Very fast Transients-Origin of VFTO-Propagation and Mechanism of VFTO-VFTO Characteristics- Effects of VFTO-Testing of GIS for VFTO.

UNIT–V: SPECIAL PROBLEMS IN GIS AND GIS DIAGNOSTICS

Introduction - particles their effects and their control- Insulating Spacers and their Reliability - SF_6 Gas Decomposition - Characteristics of imperfections in insulation - Insulation Diagnostic methods - PD Measurement and UHF Method.

TEXT BOOKS:

1. M. S. Naidu,” Gas Insulated Substations”- IK International Publishing House.
2. Hermann J. Koch, “Gas Insulated Substations”, June 2014, Wiley - IEEE Press.

REFERENCES:

1. Olivier Gallot-Lavellee, “Dielectric materials and Electrostatics” , Wiley - IEEE Press
2. Jaun Martinez, “Dielectric Materials for Electrical Engineering”, Wiley - IEEE Press

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ELECTIVE – 5.3: SMART GRID TECHNOLOGIES

Prerequisite: None

Course Objectives:

- To group various aspects of the smart grid,
- To define smart grid design to meet the needs of a utility
- To select issues and challenges that remain to be solved
- To analyze basics of electricity, electricity generation, economics of supply and demand, and the various aspects of electricity market operations in both regulated and deregulated environment.

Course Outcomes:

Upon the completion of this course, the student will be able to

- Analyze the structure of an electricity market in either regulated or deregulated market conditions.
- Know the advantages of DC distribution and developing technologies in distribution
- Discriminate the trade-offs between economics and reliability of an electric power system.
- Differentiate various investment options (e.g. generation capacities, transmission, renewable, demand-side resources, etc) in electricity markets.
- Analyze the developments of smart and intelligent domestic systems.

UNIT–I: INTRODUCTION

Introduction to smart grid - Electricity network - Local energy networks- Electric transportation - Low carbon central generation - Attributes of the smart grid - Alternate views of a smart grid.

SMART GRID TO EVOLVE A PERFECT POWER SYSTEM: Introduction- Overview of the perfect power system configurations- Device level power system- Building integrated power systems- Distributed power systems- Fully integrated power system-Nodes of innovation.

UNIT–II: DC DISTRIBUTION AND SMART GRID

AC Vs DC sources-Benefits of and drives of DC power delivery systems - Powering equipment and appliances with DC-Data centers and information technology loads - Future neighborhood-Potential future work and research.

INTELLIGRID ARCHITECTURE FOR THE SMARTGRID: Introduction- Launching intelligent grid - intelligent grid today - Smart grid vision based on the intelligent grid architecture-Barriers and enabling technologies.

UNIT–III: DYNAMIC ENERGY SYSTEMS CONCEPT

Smart energy efficient end use devices-Smart distributed energy resources - Advanced whole building control systems- Integrated communications architecture - Energy management-Role of technology in demand response- Current limitations to dynamic energy management-Distributed energy resources-Overview of a dynamic energy management-Key characteristics of smart devices- Key characteristics of advanced whole building control systems-Key characteristics of dynamic energy management system.

UNIT–IV: ENERGY PORT AS PART OF THE SMART GRID:
Concept of energy - Port, generic features of the energy port.
POLICIES AND PROGRAMS TO ENCOURAGE END – USE ENERGY EFFICIENCY: Policies and programs in action - multinational - national-state-city and corporate levels.
MARKET IMPLEMENTATION: Framework-factors influencing customer acceptance and response - program planning - monitoring and evaluation.

UNIT–V: EFFICIENT ELECTRIC END–USE TECHNOLOGY ALTERNATIVES
Existing technologies – lighting - Space conditioning - Indoor air quality - Domestic water heating - hyper efficient appliances - Ductless residential heat pumps and air conditioners - Variable refrigerant flow air conditioning-Heat pump water heating - Hyper efficient residential appliances - Data center energy efficiency- LED street and area lighting - Industrial motors and drives - Equipment retrofit and replacement - Process heating - Cogeneration, Thermal energy storage - Industrial energy management programs - Manufacturing process-Electro-technologies, Residential, Commercial and industrial sectors.

TEXT BOOKS:
1. Clark W Gellings, “The Smart Grid, Enabling Energy Efficiency and Demand Side Response”- CRC Press, 2009.
2. Jean Claude Sabonnadière, Nouredine Hadjsaïd, “Smart Grids”, Wiley-ISTE, IEEE Press, May 2012

REFERENCES:
1. Janaka Ekanayake, Kithsiri Liyanage, Jianzhong.Wu, Akihiko Yokoyama, Nick Jenkins, “Smart Grid: Technology and Applications”- Wiley, 2012.
2. James Momoh, “Smart Grid: Fundamentals of Design and Analysis” - Wiley, IEEE Press, 2012.

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ELECTIVE – 6.1: FLEXIBLE AC TRANSMISSION SYSTEMS

Prerequisite: Power Electronics and Power Systems

Course Objectives:
- To understand uncompensated lines and their behavior under heavy loading conditions.
- To understand the concept and importance controllable parameters of FACTS controllers.
- To emphasize the objectives of Shunt compensation, and basic operation of SVC and STATCOM.
- To analyze the functioning of series controllers like GCSC, TSSC and TCSC

Course Outcomes:
Upon the completion of this course, the student will be able to
- Choose proper controller for the specific application based on system requirements
- Understand various systems thoroughly and their requirements
- Interpret the control circuits of Shunt Controllers SVC & STATCOM for various functions viz. Transient stability Enhancement, voltage instability prevention and power oscillation damping
- Detect the Power and control circuits of Series Controllers GCSC, TSSC and TCSC

UNIT-I: FACTS CONCEPTS
Transmission interconnections power flow in an AC system, loading capability limits, Dynamic stability considerations, importance of controllable parameters basic types of FACTS controllers, benefits from FACTS controllers.

UNIT-II: VOLTAGE SOURCE CONVERTERS
Single phase & three phase full wave bridge converters, transformer connections for 12 pulse 24 and 48 pulse operation. Three level voltage source converter, pulse width modulation converter, basic concept of current source Converters, and comparison of current source converters with voltage source converters.

UNIT-III: STATIC SHUNT COMPENSATION
Objectives of shunt compensation, mid-point voltage regulation, voltage instability prevention, improvement of transient stability, Power oscillation damping, Methods of controllable VAR generation, variable impedance type static VAR generators switching converter type VAR generators, hybrid VAR generators.

UNIT-IV: SVC AND STATCOM
The regulation and slope transfer function and dynamic performance, transient stability enhancement and power oscillation damping operating point control and summary of compensator control.

UNIT-V: STATIC SERIES COMPENSATORS
Concept of series capacitive compensation, improvement of transient stability, power oscillation damping, and functional requirements of GTO thyristor controlled series capacitor

(GSC), thyristor switched series capacitor (TSSC), and thyristor controlled series capacitor (TCSC)
Control schemes for GSC, TSSC and TCSC.

TEXT BOOKS:

1. Hingorani H G and Gyugyi. L " Understanding FACTS-Concepts and Technology of Flexible AC Transmission Systems" New York, IEEE Press, 2000.
2. Padiyar.K.R, " FACTS Controllers in Power Transmission and Distribution" New Age Int. Publishers, 2007

REFERENCES:

1. Zhang, Xiao-Ping, Rehtanz, Christian, Pal, Bikash "Flexible AC Transmission Systems: Modeling and Control", Springer, 2012
2. Yong-Hua Song, Allan Johns, "Flexible AC Transmission Systems", IET, 1999.

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ELECTIVE – 6.2: POWER SYSTEM RELIABILITY

Prerequisite: Reliability Engineering

Course Objectives:
- To describe the generation system model and recursive relation for capacitive model building
- To explain the equivalent transitional rates, cumulative probability and cumulative frequency
- To develop the understanding of risk, system and load point reliability indices
- To explain the basic and performance reliability indices

Course Outcomes: Upon the completion of this course, the student will be able to
- Estimate loss of load and energy indices for generation systems model
- Describe merging generation and load models
- Apply various indices for distribution systems
- Evaluate reliability of interconnected systems

UNIT-I: GENERATING SYSTEM RELIABILITY ANALYSIS – I
Generation system model – capacity outage probability tables – Recursive relation for capacitive model building – sequential addition method – unit removal – Evaluation of loss of load and energy indices – Examples.

UNIT-II: GENERATING SYSTEM RELIABILITY ANALYSIS – II
Frequency and Duration methods – Evaluation of equivalent transitional rates of identical and non-identical units – Evaluation of cumulative probability and cumulative frequency of non-identical generating units – 2-level daily load representation - merging generation and load models – Examples.

UNIT-III: OPERATING RESERVE EVALUATION
Basic concepts - risk indices – PJM methods – security function approach – rapid start and hot reserve units – Modeling using STPM approach.
BULK POWER SYSTEM RELIABILITY EVALUATION:
Basic configuration – conditional probability approach – system and load point reliability indices – weather effects on transmission lines – Weighted average rate and Markov model – Common mode failures.

UNIT-IV: INTER CONNECTED SYSTEM RELIABILITY ANALYSIS
Probability array method – Two inter connected systems with independent loads – effects of limited and unlimited tie capacity - imperfect tie – Two connected Systems with correlated loads – Expression for cumulative probability and cumulative frequency.

UNIT-V: DISTRIBUTION SYSTEM RELIABILITY ANALYSIS
Basic Techniques – Radial networks –Evaluation of Basic reliability indices, performance indices – load point and system reliability indices – customer oriented, loss and energy oriented indices – Examples. Basic concepts of parallel distribution system reliability
Substations and Switching Stations:

Effects of short-circuits - breaker operation – Open and Short-circuit failures – Active and Passive failures – switching after faults – circuit breaker model – preventive maintenance – exponential maintenance times.

TEXT BOOKS:

1. Reliability Evaluation of Power systems by R. Billinton, R.N.Allan, BS Publications, 2007.
2. Reliability Modeling in Electric Power Systems by J. Endrenyi, John Wiley and Sons, 1978

REFERENCES:

1. Reliability Engineering: Theory and Practice by Alessandro Birolini, Springer Publications.
2. An Introduction to Reliability and Maintainability Engineering by Charles Ebeling, TMH Publications.
3. Reliability Engineering by E. Balaguruswamy, TMH Publications.
4. Reliability Engineering by Elsayed A. Elsayed, Prentice Hall Publications.

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ELECTIVE – 6.3: DIGITAL CONTROL SYSTEMS

Prerequisite: None

Course Objectives:

- To explain basic and digital control system for the real time analysis and design of control systems.
- To apply the knowledge state variable analysis in the design of discrete systems.
- To explain the concept of stability analysis and design of discrete time systems.

Course Outcomes:

Upon the completion of this course, the student will be able to

- Apply the concepts of Digital control systems.
- Analyze and design of discrete systems in state variable analysis.
- To relate the concepts of stability analysis and design of discrete time systems.

UNIT – I: Concept & Representation of Discrete time Systems

Block Diagram of typical control system- advantages of sampling in control systems – examples of discrete data and digital systems – data conversion and quantization – sample and hold devices – D/A and A/D conversion – sampling theorem – reconstruction of sampled signals.

Z-transform: Definition of Z-transforms – mapping between s-plane and z-plane – inverse z-transform – properties of z-transforms - ROC of z-transforms –pulse transfer function –relation between G(s) and G(z) – signal flow graph method applied to digital control systems.

UNIT- II: STATE SPACE ANALYSIS:

State space modeling of discrete time systems – state transition equation of discrete time invariant systems – solution of time invariant discrete state equations: recursive method and the Z-Transformation method – conversion of pulse transfer function to the state model & vice-versa – Eigen values – Eigen vectors of discrete time system-matrix (A) – Realization of pulse transformation in state space form, discretization of continuous time systems, Computation of state transition matrix and its properties. Response of sample data system between sampling instants.

UNIT – III: CONTROLLABILITY, OBSERVABILITY & STABILITY TESTS

Concept of controllability, stabilizability, observability and reachability - Controllability and observability tests, Transformation of discrete time systems into controllable and observable forms.

Stability: Definition of stability – stability tests – The second method of Liapunov.

UNIT- IV: DESIGN OF DISCRETE TIME CONTROLLERS AND OBSERVERS

Design of discrete time controller with bilinear transformation – Realizatiion of digital PID controller-Design of deadbeat controller; Pole placement through state feedback.

UNIT-V: STATE OBSERVERS:

Design of Full order and reduced order observers. Study of observer based control design.

TEXT BOOKS:

1. K. Ogata , Discrete-Time Control systems, Pearson Education/PHI, 2nd Edition.
2. V. I. George, C. P. Kurian, Digital Control Systems, Cengage Learning.
3. M.Gopal, Digital Control Engineering, New Age Int. Pvt. Ltd., 2014

REFERENCES:

1. Kuo, Digital Control Systems, Oxford University Press, 2nd Edition, 2003.
2. M.Gopal , Digital Control and State Variable Methods, TMH.
3. M. Sami Fadali Antonio Visioli, Digital Control Engineering Analysis and Design, Academic Press

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ELECTIVE – 7.1: POWER QUALITY

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 phase unbalanced voltage sag.
- To know the behavior of power electronics loads, induction motors, synchronous motor 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 (higher voltages) 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 power quality, power quality monitoring.

UNIT-II: LONG & SHORT INTERRUPTIONS
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-PHASE & THREE-PHASE VOLTAGE SAG CHARACTERIZATION
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
Voltage sag – equipment behavior of Power electronic loads, induction motors, synchronous motors, computers, consumer electronics, adjustable speed AC drives and its operation.

Mitigation of AC Drives, adjustable speed DC drives and its operation, mitigation methods of DC drives.

UNIT-V: MITIGATION OF INTERRUPTIONS & VOLTAGE SAGS
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.

POWER QUALITY AND EMC STANDARDS:
Introduction to standardization, IEC Electromagnetic compatibility standards, European voltage characteristics standards, PQ surveys.

TEXTBOOKS:

1. Math H J Bollen “Understanding Power Quality Problems”, IEEE Press.
2. R.C. Dugan, M.F. Mc Granaghan 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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ELECTIVE – 7.2: SOLAR PHOTO VOLTAIC SYSTEMS

Pre-requisite: None

Course Objectives: Objectives of this course are

- To introduce photovoltaic systems
- To deal with various technologies of Solar PV cells
- To understand details about manufacturizing and operating techniques
- To have knowledge of design considerations.

Course Outcomes:

After this course, the student will be able to

- Identify photovoltaic system components and system types
- Calculate electrical energy and power
- Correctly size system components, design considerations of solar equipment
- Design a basic grid interactive PV system.

UNIT – I

SOLAR ENERGY: Sun and Earth, Solar Spectrum, Solar Geometry, Solar radiation on horizontal and inclined planes, Instruments for measurement of solar radiation ,Solar cell, Equivalent circuit, V-I characteristics, Performance improvement.

UNIT – II

SOLAR CELLS: Manufacture of Solar Cells-Technologies, Design of Solar cells, Photovoltaic modules, Design requirements, encapsulation systems, manufacture, power rating, hotspot effect, Design qualifications.

UNIT – III

PROTECTION AND MEASUREMENTS: Flat plate arrays, support structures, module interconnection and cabling, lightning protection, Performance measurement – using natural sun light and simulator, determination of temperature coefficients, internal series resistance, curve correction factor.

UNIT - IV

PHOTOVOLTAIC SYSTEMS: Photovoltaic systems- types- general design considerations-system sizing-battery sizing- inverter sizing-design examples – Balance of PV systems.

UNIT – V

MAXIMUM POWER POINT TRACKERS: Maximum power point trackers-algorithms-perturb and observe-incremental conductance method, hill climbing method, hybrid and complex methods, data based and other approximate methods, instrument design, other MPP techniques-Grid interactive PV system.

TEXT BOOKS:

1. Generating electricity from Sun, F.C.Treble, Pergamon Press
2. Photvolatic systems: Analysis and design, A.K.Mukherjee, Nivedita Thakur, PHI 2011
3. Solar Photovoltaics: Fundamentals, Technologies and applications, C.S.Solanki, PHI, 2009

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ELECTIVE – 7.3: DISTRIBUTION AUTOMATION

Prerequisite: Electrical Distribution Systems

Course objectives:
- To list the distribution systems for load modeling
- To understand the design & working of substations.
- To compute system protection
- To give a comprehensive idea on communication systems.

Course Outcomes:
Upon the completion of this course, the student will be able to
- Find the transfer of electrical data in distribution system through Digital Communication.
- Predict load forecasting and reliability in economic point of view
- Apply Distribution Automation objectives and SCADA
- To have a knowledge on management of different electrical parameters.

UNIT-I: DISTRIBUTION AUTOMATION AND THE UTILITY SYSTEM
Introduction to Distribution Automation (DA), control system interfaces, control and data requirements, centralized (Vs) decentralized control, DA System (DAS), DA Hardware, DAS software.

UNIT-II: DISTRIBUTION AUTOMATION FUNCTIONS
DA capabilities, Automation system computer facilities, management processes, Information management, system reliability management, system efficiency management, voltage management, Load management.

UNIT-III: COMMUNICATION SYSTEMS FOR DISTRIBUTION AUTOMATION (DA)
DA communication requirements, Communication reliability, Cost effectiveness, Data rate Requirements, Two way capability, Ability to communicate during outages and faults, Ease of operation and maintenance, Conforming to the architecture of data flow
Communication systems used in DA : Distribution line carrier (Power line carrier), Ripple control, Zero crossing technique, telephone, cable TV, Radio, AM broadcast, FM SCA, VHF Radio, UHF Radio, Microwave satellite. Fiber optics, Hybrid Communication systems, Communication systems used in field tests.

UNIT-IV: TECHNICAL BENEFITS
DA benefit categories, Capital deferred savings, Operation and Maintenance savings, Interruption related savings, Customer related savings, Operational savings, improved operation, Function benefits, Potential benefits for functions, and function shared benefits, Guidelines for formulation of estimating equations Parameters required, economic impact areas, Resources for determining benefits impact on distribution system, integration of benefits into economic evaluation.

UNIT-V: ECONOMIC EVALUATION METHODS
Development and evaluation of alternate plans, Select study area, Select study period, Project load growth, Develop Alternatives, Calculate operating and maintenance costs, Evaluate alternatives. Economic comparison of alternate plans, Classification of expenses

and capital expenditures, Comparison of revenue requirements of alternative plans, Book Life and Continuing plant analysis, Year by year revenue requirement analysis, short term analysis, end of study adjustment, Break even analysis, Sensitivity analysis computational aids.

TEXT BOOKS:

1. Control and Automation of Electrical Distribution Systems, James. Northcote – Green Robert Wilson, CRC Press.
2. Electric Power Distribution Automation, Dr. M. K. Khedkar, Dr. G.M.Dhole, University Science press.

REFERENCES:

1. IEEE Tutorial Course “Distribution Automation”
2. IEEE Working Group on “Distribution Automation”

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ELECTIVE – 8.1: PROGRAMMABLE LOGIC CONTROLLERS AND APPLICATIONS

Prerequisite: None

Course Objectives:
- To analyze Programmable Logic Controller (PLC), IO Modules and internal features.
- To Comprehend Programming in Ladder Logic, addressing of I/O and interfacing of modules for applications.
- To apply PID and its Tuning.

Course Outcomes:
Upon the completion of this course, the student will be able to
- Describe the main functional units in a PLC and be able to explain how they interact.
- Development of ladder logic programming and interface modules
- Development of PLC based applications.

UNIT-I:
PLC Basics PLC system, I/O modules and interfacing CPU processor programming equipment programming formats, construction of PLC ladder diagrams, devices connected to I/O modules.

UNIT-II:
PLC Programming input instructions, outputs, operational procedures, programming examples using contacts and coils. Drill-press operation.
Digital logic gates programming in the Boolean algebra system, conversion examples Ladder diagrams for process control Ladder diagrams and sequence listings, ladder diagram construction and flow chart for spray process system.

UNIT-III:
PLC Registers: Characteristics of Registers module addressing holding registers input registers, output registers. PLC Functions Timer functions and industrial applications counters counter function industrial applications, Architecture functions, Number comparison functions, number conversion functions.

UNIT-IV:
Data handling functions: SKIP, Master control Relay Jump Move FIFO, FAL, ONS, CLR and Sweep functions and their applications. Bit Pattern and changing a bit shift register, sequence functions and applications, controlling of two axes and three axis Robots with PLC, Matrix functions.

UNIT-V:
Analog PLC operation: Analog modules and systems Analog signal processing multi bit data processing , analog output application examples, PID principles position indicator with PID control, PID modules, PID tuning, PID functions

TEXT BOOKS:

1. Programmable Logic Controllers – Principle and Applications by John W. Webb & Ronald A. Reiss, Fifth Edition, PHI
2. Digital Design by Morris Mano, PHI, 3rd Edition 2006.

REFERENCES:

1. Programmable logic Controllers, Frank D. Petruzella, 4th Edition, McGraw Hill Publishers.
2. Programmable Logic Controllers – Programming Method and Applications by JR. Hackworth & F.D Hackworth Jr. – Pearson, 2004.
3. Programmable logic controllers and their Engineering Applications, 2nd Edition, Alan J. Crispin.

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ELECTIVE – 8.2: AI TECHNIQUES IN ELECTRICAL ENGINEERING

Prerequisite: None

Course Objectives:
- To locate soft commanding methodologies, such as artificial neural networks, Fuzzy logic and genetic Algorithms.
- To observe the concepts of feed forward neural networks and about feedback neural networks.
- To practice the concept of fuzziness involved in various systems and comprehensive knowledge of fuzzy logic control and to design the fuzzy control
- To analyze genetic algorithm, genetic operations and genetic mutations.

Course Outcomes:
Upon the completion of this course, the student will be able to
- Understand feed forward neural networks, feedback neural networks and learning techniques.
- Understand fuzziness involved in various systems and fuzzy set theory.
- Develop fuzzy logic control for applications in electrical engineering
- Develop genetic algorithms for applications in electrical engineering.

UNIT – I: ARTIFICIAL NEURAL NETWORKS
Introduction-Models of Neural Network - Architectures – Knowledge representation – Artificial Intelligence and Neural networks – Learning process – Error correction learning – Hebbian learning – Competitive learning – Boltzman learning – Supervised learning – Unsupervised learning – Reinforcement learning - learning tasks.

UNIT- II: ANN PARADIGMS
Multi – layer perceptron using Back propagation Algorithm-Self – organizing Map – Radial Basis Function Network – Functional link, network – Hopfield Network.

UNIT – III: FUZZY LOGIC
Introduction – Fuzzy versus crisp – Fuzzy sets - Membership function – Basic Fuzzy set operations – Properties of Fuzzy sets – Fuzzy cartesian Product – Operations on Fuzzy relations – Fuzzy logic – Fuzzy Quantifiers - Fuzzy Inference - Fuzzy Rule based system - Defuzzification methods.

UNIT – IV: GENETIC ALGORITHMS
Introduction-Encoding – Fitness Function-Reproduction operators - Genetic Modeling – Genetic operators - Crossover - Single–site crossover – Two-point crossover – Multi point crossover-Uniform crossover – Matrix crossover - Crossover Rate - Inversion & Deletion – Mutation operator –Mutation – Mutation Rate-Bit-wise operators-Generational cycle-convergence of Genetic Algorithm.

UNIT–V: APPLICATIONS OF AI TECHNIQUES
Load forecasting – Load flow studies – Economic load dispatch – Load frequency control –
Single area system and two area system – Small Signal Stability (Dynamic stability)
Reactive power control – speed control of DC and AC Motors.

TEXT BOOKS:

1. S.Rajasekaran and G.A.V.Pai, “Neural Networks, Fuzzy Logic & Genetic Algorithms”- PHI, New Delhi, 2003.

REFERENCES:

1. P.D.Wasserman,Van Nostrand Reinhold,’”Neural Computing Theory & Practice”, New York,1989.
2. Bart Kosko, “Neural Network & Fuzzy System”, Prentice Hall, 1992.
3. G.J.Klir and T.A.Folger, “Fuzzy sets, Uncertainty and Information”, PHI, Pvt.Ltd, 1994.
4. D.E.Goldberg, “Genetic Algorithms”, Addison Wesley 1999.

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ELECTIVE – 8.3: ENERGY EFFICIENT SYSTEMS

Prerequisite: Power Systems

Course Objectives:
- To have basic concepts of Electrical systems, motors, generating systems.
- To illustrate the application of Electrical systems in PF improvement scheme
- To illustrate the application of pumps and pumping system.

Course Outcomes:
Upon the completion of this course, the student will be able to
- Understand the advantages of Electrical system and its basic components.
- Understand the implementation of Energy Efficient Technologies in Electrical Systems

UNIT-I:
ELECTRICAL SYSTEM: Electricity billing, Electrical Load Management and maximum demand control, Power factor improvement and its benefit, Selection and location of capacitors, Performance assessment of PF capacitors, Distribution and Transformer losses.

UNIT-II:
ELECTRIC MOTORS: Types, Losses in Electric Motors, motor efficiency, factors affecting motor performance, rewinding and motor replacement issues, energy saving opportunities with energy efficient motors.
LIGHTING SYSTEM: Light source, choice of lighting, luminance requirements, and energy conservation avenues. Energy efficient lighting controls, comparison of sodium vapor, halogen, CFL and LED lamps.

UNIT-III:
COMPRESSED AIR SYSTEM: Types of air compressors, compressor efficiency, efficient compressor operation, compressed air system components, capacity assessment, leakage test, factors affecting the performance and savings opportunities.
HVAC AND REFRIGERATION SYSTEM: Vapor compression refrigeration cycle, refrigerants, coefficient of performance, capacity, factors affecting refrigeration and air-conditioning system performance and saving opportunities, vapor absorption refrigeration system - working principle, types and comparison with vapor compression system, saving potential Fans and Blowers: Types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities.

UNIT-IV:
PUMPS AND PUMPING SYSTEM: Types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities.
COOLING TOWER: Types and performance evaluation, efficient system operation, flow control strategies, energy saving opportunities, Assessment of cooling tower.

UNIT-V:
DIESEL GENERATING SYSTEM: Factors affecting selection, energy performance assessment of diesel conservation avenues.
ENERGY EFFICIENT TECHNOLOGIES IN ELECTRICAL SYSTEMS: Maximum Demand Controllers, automatic power factor controllers, energy efficient motors, soft starters with

energy saver, variable speed drives, energy efficient transformers, electronic ballast, occupancy sensors, energy saving potential of each technology. Calculation of energy frequency ratio in the performance of star ratings.

TEXT BOOKS:

1. Eastop T.D & Croft D.R, Energy Efficiency for Engineers and Technologists,. Logman Scientific & Technical, ISBN-0-582-03184, 1990.
2. Reay D.A, Industrial Energy Conservation, 1stedition, Pergamon Press, 1977.

REFERENCE:

1. Larry C Whitetal, Industrial Energy Management & Utilization.
2. Power System Engineering 2nd Ed. D P Kothari, I J Nagrath, Tata McGraw-Hill Co 2008
3. Bureau of Energy Efficiency (BEE) : www.bee-india.nic.in
4. The Energy and Resource Institute (TERI): http://www.teriin.org/
5. Energy Efficiency for Engineers and Technologists, First Edition, 1990, by TD Eastop and DR Croft, Longman Group UK Ltd.
6. Industrial Energy Management and Utilization, 1988, by LC Wittie, P S Schmidt and D R Brown, Hemisphere Publishing Company. 3. Energy Management Hand Book, Third Edition, 1997, by W C Turner, the Fairmont Press Inc.
7. www.bee-india.nic.in (Guide on Energy Efficient room Air conditioners)

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ELECTIVE – 8.4: SOFTWARE ENGINEERING

Prerequisites

1. A course on “Computer Programming and Data Structures”
2. A course on “Object Oriented Programming Through Java”

Objectives

1. The aim of the course is to provide an understanding of the working knowledge of the techniques for estimation, design, testing and quality management of large software development projects.
2. Topics include process models, software requirements, software design, software testing, software process/product metrics, risk management, quality management and UML diagrams

Outcomes

1. Ability to translate end-user requirements into system and software requirements, using e.g. UML, and structure the requirements in a Software Requirements Document (SRD).
2. Identify and apply appropriate software architectures and patterns to carry out high level design of a system and be able to critically compare alternative choices.
3. Will have experience and/or awareness of testing problems and will be able to develop a simple testing report

UNIT-I:

INTRODUCTION TO SOFTWARE ENGINEERING: The evolving role of software, changing nature of software, software myths.

A GENERIC VIEW OF PROCESS: Software engineering- a layered technology, a process framework, the capability maturity model integration (CMMI), process patterns, process assessment, personal and team process models.

Process models: The waterfall model, incremental process models, evolutionary process models, the unified process.

UNIT-II:

SOFTWARE REQUIREMENTS: Functional and non-functional requirements, user requirements, system requirements, interface specification, the software requirements document.

REQUIREMENTS ENGINEERING PROCESS: Feasibility studies, requirements elicitation and analysis, requirements validation, requirements management.

SYSTEM MODELS: Context models, behavioral models, data models, object models, structured methods.

UNIT-III:

DESIGN ENGINEERING: Design process and design quality, design concepts, the design model.

CREATING AN ARCHITECTURAL DESIGN: software architecture, data design, architectural styles and patterns, architectural design, conceptual model of UML, basic structural modeling, class diagrams, sequence diagrams, collaboration diagrams, use case diagrams, component diagrams.

UNIT-IV:

TESTING STRATEGIES: A strategic approach to software testing, test strategies for conventional software, black-box and white-box testing, validation testing, system testing, the art of debugging.

PRODUCT METRICS: Software quality, metrics for analysis model, metrics for design model, metrics for source code, metrics for testing, metrics for maintenance.

UNIT-V:

METRICS FOR PROCESS AND PRODUCTS: Software measurement, metrics for software quality.

RISK MANAGEMENT: Reactive Vs proactive risk strategies, software risks, risk identification, risk projection, risk refinement, RMMM, RMMM plan.

QUALITY MANAGEMENT: Quality concepts, software quality assurance, software reviews, formal technical reviews, statistical software quality assurance, software reliability, the ISO 9000 quality standards.

TEXT BOOKS:

1. Software Engineering, A practitioner's Approach- Roger S. Pressman, 6^{th} edition, Mc Graw Hill International Edition.
2. Software Engineering- Sommerville, 7^{th} edition, Pearson Education.
3. The unified modeling language user guide Grady Booch, James Rambaugh, Ivar Jacobson, Pearson Education.

REFERENCES:

1. Software Engineering, an Engineering approach- James F. Peters, Witold Pedrycz, John Wiley.
2. Software Engineering principles and practice- Waman S Jawadekar, The Mc Graw-Hill Companies.
3. Fundamentals of object oriented design using UML Meiler page-Jones: Pearson Education.

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ELECTIVE – 8.5: ENERGY STORAGE TECHNOLOGIES

Prerequisite: Power Systems

Course Objectives:

- To know about the Demand for Energy Storage.
- To study the roles of electrical energy storage technologies in electricity.
- To analyze the features of energy storage systems.

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

- Evaluate various techniques for storing electrical energy.
- Understand the features of storage systems and apply them for conventional power generation, grid operation & service.

UNIT-I:
THE ROLE OF ELECTRICAL ENERGY STORAGE TECHNOLOGIES IN ELECTRICITY USE: Characteristics of electricity, Electricity and the role of EES, High generation cost during peak-demand periods. Need for continuous and flexible supply, Long distance between generation and consumption, Congestion in power grids, Transmission by cable, Emerging needs for EES, More renewable energy, less fossil fuel, Smart Grid uses, The role of electrical energy storage technologies, The role from the viewpoint of a utility, The role from the viewpoint of consumers, The role from the viewpoint of generators of renewable energy.

UNIT-II:
TYPES AND FEATURES OF ENERGY STORAGE SYSTEMS: Classification of EES systems, Mechanical storage systems, Pumped hydro storage (PHS), Compressed air energy storage (CAES), Flywheel energy storage (FES), Electrochemical storage systems, Secondary batteries, Lead-Acid Batteries, Lithium-Ion Batteries, Flow batteries, Other Batteries in Development, Chemical energy storage, Hydrogen (H2), Synthetic natural gas (SNG), Electrical storage systems, Double-layer capacitors (DLC), Superconducting magnetic energy storage (SMES),Thermal storage systems, Standards for EES, Technical comparison of EES technologies.

UNIT-III:
APPLICATIONS OF EES: Present status of applications, Utility use (conventional power generation, grid operation & service), Consumer use (uninterruptable power supply for large consumers), EES installed capacity worldwide, New trends in applications, Renewable energy generation, Smart Grid, Smart Microgrid, Smart House, Electric vehicles,

UNIT-IV:
MANAGEMENT AND CONTROL HIERARCHY OF EES: Internal configuration of battery storage systems, External connection of EES systems, Aggregating EES systems and distributed generation (Virtual Power Plant), “Battery SCADA” – aggregation of many dispersed batteries.
DEMAND FOR ENERGY STORAGE: Growth in Variable Energy Resources, Relationship between balancing services and variable energy resources, Energy Storage Alternatives,

Variable Generator Control, Demand Management, Market Mechanisms, Longer Term Outlook.
VALUATION TECHNIQUES: Overview, Energy Storage Operational Optimization, Market Price Method, Power System Dispatch Model Method, Ancillary Service Representation, Energy Storage Representation, Survey of Valuation Results.

UNIT-V:
FORECAST OF EES MARKET POTENTIAL BY 2030: EES market potential for overall applications, EES market estimation by Sandia National Laboratory (SNL), EES market estimation by the Boston Consulting Group (BCG), EES market estimation for Li-ion batteries by the Panasonic Group, EES market potential estimation for broad introduction of renewable energies, EES market potential estimation for Germany by Fraunhofer, Storage of large amounts of energy in gas grids, EES market potential estimation for Europe by Siemens, EES market potential estimation by the IEA, Vehicle to grid concept, EES market potential in the future

TEXT BOOKS:
1. Techno-Economic Analysis of Different Energy Storage Technologies, Hussein Ibrahim and Adrian Ilinca
2. Energy Storage 2010th Edition, by Robert A. Huggins (Author), Springer
3. Energy Storage, Yves Brunet (Editor), May 2013, Wiley-ISTE
4. Energy Storage in Electric Power Grids ,by Benoît Robyns, Bruno François, Wiley

REFERENCES:
1. andreasoberhofer@gmx.de
2. www.ecofys.com/com/publications
3. www.iec.ch

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ELECTIVE – 8.6: ELECRICAL ENGINEERING MATERIALS

Prerequisite: None

Course Objectives:

- To know the properties, characteristics of dielectric materials.
- To study the properties, characteristics of dielectric materials.
- To analyze the properties, characteristics of semiconductor materials.
- To discuss the different kind of materials for electric applications.
- To have a glance on the properties, characteristics of special materials.

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

- Evaluate insulating, conducting and magnetic materials used in electrical machines.
- Understand the properties of liquid, gaseous and solid insulating materials.
- Evaluate transformer oil by testing

UNIT-I:
DIELECTRIC MATERIALS
Dielectric as Electric Field Medium, leakage currents, dielectric loss, dielectric strength, breakdown voltage, breakdown in solid dielectrics, flashover, liquid dielectrics, electric conductivity in solid, liquid and gaseous dielectrics, Ferromagnetic materials, properties of ferromagnetic materials in static fields, spontaneous, Polarization, Curie point, anti-ferromagnetic materials, piezoelectric materials, pyroelectric materials.

UNIT-II:
MAGNETIC MATERIALS
Classification of magnetic materials, spontaneous magnetization in ferromagnetic materials, magnetic Anisotropy, Magnetostriction, diamagnetism, magnetically soft and hard materials, special purpose materials, feebly magnetic materials, Ferrites, cast and cermet permanent magnets, ageing of magnets. Factors effecting permeability and hysteresis.

UNIT-III:
SEMICONDUCTOR MATERIALS
Properties of semiconductors, Silicon wafers, integration techniques, Large and very large scale integration techniques (VLSI).

UNIT-IV:
MATERIALS FOR ELECTRICAL APPLICATIONS
Materials used for Resistors, rheostats, heaters, transmission line structures, stranded conductors, bimetals fuses, soft and hard solders, electric contact materials, electric carbon materials, thermocouple materials. Solid Liquid and Gaseous insulating materials. Effect of moisture on insulation.

UNIT-V:
SPECIAL PURPOSE MATERIALS
Refractory Materials, Structural Materials, Radioactive Materials, Galvanization and Impregnation of materials, Processing of electronic materials, Insulating varnishes and coolants, Properties and applications of mineral oils, Testing of Transformer oil as per ISI.

TEXT BOOKS:

1. R K Rajput: A course in Electrical Engineering Materials, Laxmi Publications. 2009
2. T K BasaK: A course in Electrical Engineering Materials:, New Age Science Publications 2009

REFRENCE:

1. TTTI Madras: Electrical Engineering Materials
2. Adrianus J.Dekker: Electrical Engineering Materials, TMH Publication

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POWER SYSTEMS LAB

Course Objectives:

Upon successful completion of the lab students will be familiar with:

- Equivalent circuit of 3-winding transformer, rotating machines
- Sequence impedances
- Different types of Faults occurring in power systems
- Characteristics of different types of relays
- Sub transient reactance's of electrical equipments
- Protection schemes

Course Outcomes:

At the end of the course, the student should be able to:

- Determine equivalent circuit parameters of electrical equipments
- Determine sequence impedances of electrical equipments
- Calculate various faults
- Calculate sub-transient reactance's of rotating machines
- Analyze the various time-current characteristics of protective relays
- Know the Performance and Testing of various electrical models and systems

1. Determination of Equivalent circuit of a 3-Winding Transformer.
2. Determination of Sequence Impedances of a Cylindrical Rotor Synchronous Machine.
3. Fault Analysis:
   i. Single Line to Ground fault (L-G).
   ii. Line to Line fault (L-L).
   iii. Double Line to Ground fault (L-L-G).
   iv. Triple Line to Ground fault (L-L-L-G).
4. Determination of Sub-transient reactance's of a Salient Pole Synchronous Machine.
5. Determination of Sequence Impedances of Three Phase Transformer
6. Characteristics of Over Current Relays
   i. IDMT Electromagnetic Relay (7051 A).
   ii. Microprocessor based Relay (7051 B)
7. Characteristics of Percentage biased Differential Relay.
   i. Electromagnetic Relay (7054 A).
   ii. Static Relay (7054 B).
8. Characteristics of Over Voltage Relay.
   i. Electromagnetic Relay (7053 A).
   ii. Microprocessor based Relay (7053 B).

9. Characteristics of Under Voltage (UV) and Negative sequence Relays
    i. UV Electromagnetic Relay (7052 A).
    ii. UV Microprocessor based Relay (7052 B).
    iii. Static Negative Sequence Relay (7055 B).
10. Performance and Testing of Generator Protection System.
11. Performance and Testing of Transformer Protection System.
12. Performance and Testing of Feeder Protection System.
13. Performance and Testing of Transmission Line Model.
14. Differential protection on Single Phase Transformer.

Note: From the above list minimum 10 experiments are to be conducted