

**IV Year – I SEMESTER**

T	P	C
3+1	0	3

**RENEWABLE ENERGY SOURCES AND SYSTEMS****Preamble:**

This course gives a flavor of renewable sources and systems to the students. It introduces solar energy its radiation, collection, storage and its applications. This covers generation, design, efficiency and characteristics of various renewable energy sources including solar, wind, hydro, biomass, fuel cells and geothermal systems.

**Learning Objectives:**

- To study the solar radiation data, extra terrestrial radiation, radiation on earth's surface.
- To study solar thermal collections.
- To study solar photo voltaic systems.
- To study maximum power point techniques in solar pv and wind.
- To study wind energy conversion systems, Betz coefficient, tip speed ratio.
- To study basic principle and working of hydro, tidal, biomass, fuel cell and geothermal systems.

**UNIT-I:****Fundamentals of Energy Systems**

Energy conservation principle – Energy scenario (world and India) – Solar radiation: Outside earth's atmosphere – Earth surface – Analysis of solar radiation data – Geometry – Radiation on tilted surfaces – Numerical problems.

**UNIT-II:****Solar Thermal Systems**

Liquid flat plate collections: Performance analysis – Transmissivity – Absorptivity product collector efficiency factor – Collector heat removal factor – Numerical problems. Introduction to solar air heaters – Concentrating collectors and solar pond.

**UNIT-III:****Solar Photovoltaic Systems**

Balance of systems – IV characteristics – System design: storage sizing – PV system sizing – Maximum power point techniques: Perturb and observe (P&O) technique – Hill climbing technique.

**UNIT-IV:****Wind Energy**

Wind patterns – Types of turbines – Kinetic energy of wind – Betz coefficient – Tip-speed ratio – Efficiency – Power output of wind turbine – Selection of generator(synchronous, induction) – Maximum power point tracking.

**UNIT-V:****Hydro and Tidal power systems**

Basic working principle – Classification of hydro systems: Large, small, micro – measurement of head and flow – Energy equation – Types of turbines – Numerical problems.

Tidal power – Basics – Kinetic energy equation – Numerical problems – Wave power – Basics – Kinetic energy equation.

**UNIT-VI:****Biomass, fuel cells and geothermal systems**

Biomass Energy: Fuel classification – Pyrolysis – Direct combustion of heat – Different digesters and sizing.

Fuel cell: Classification – Efficiency – VI characteristics.

Geothermal: Classification – Dry rock and aquifer – Energy analysis.

**Learning Outcomes:**

Student should be able to

- Analyze solar radiation data, extraterrestrial radiation, radiation on earth's surface.
- Design solar thermal collections.
- Design solar photo voltaic systems.
- Develop maximum power point techniques in solar PV and wind.
- Explain wind energy conversion systems, Betz coefficient, tip speed ratio.
- Explain basic principle and working of hydro, tidal, biomass, fuel cell and geothermal systems.

**Text Books:**

1. Solar Energy: Principles of Thermal Collection and Storage, S. P. Sukhatme and J. K. Nayak, TMH, New Delhi, 3<sup>rd</sup> Edition.
2. Renewable Energy Resources, John Twidell and Tony Weir, Taylor and Francis -second edition, 2013.
3. Energy Science: Principles, Technologies and Impacts, John Andrews and Nick Jelly, Oxford.

**Reference Books:**

1. Renewable Energy- Edited by Godfrey Boyle-oxford university, press, 3<sup>rd</sup> edition, 2013.
2. Handbook of renewable technology Ahmed and Zobaa, Ramesh C Bansal, World scientific, Singapore.
3. Renewable Energy Technologies /Ramesh & Kumar /Narosa.
4. Renewable energy technologies – A practical guide for beginners – Chetong Singh Solanki, PHI.
5. Non conventional energy source –B.H. Khan- TMH-2<sup>nd</sup> edition.

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**HVAC & DC TRANSMISSION****Preamble:**

With the increasing power generation in the country and long distance power transmission, it is necessary that power should be transmitted at extra and ultra high voltage. The topics dealt in this subject relate to phenomena associated with transmission line at higher voltages, equipments generating high voltage and power control strategy.

**Learning Objectives:**

- To understand the phenomena associated with transmission line, operating at extra high voltages. The unit gives detail analysis of several phenomena viz. electrostatic field, charges, voltage gradient and conductor configuration.
- The objective is to discuss phenomena of corona, losses, audible noise, radio interference and measurement of these quantities.
- To understand the phenomena of HVDC, HVDC equipment comparison with AC and the latest state of art in HVDC transmission.
- To understand method of conversion of AC to DC, performance of various level of pulse conversion and control characteristics of conversion. It also provides knowledge of effect of source inductance as well as method of power control.
- To understand the requirements of reactive power control and filtering technique in HVDC system.
- To understand the harmonics in AC side of power line in a HVDC system and design of filters for various levels of pulse conversion.

**UNIT – I:****Introduction of EHV AC transmission**

Necessity of EHV AC transmission – Advantages and problems – Power handling capacity and line losses – Mechanical considerations – Resistance of conductors –Electrostatics – Field of sphere gap – Field of line charges and properties – Charge ~ potential relations for multi-conductors – Surface voltage gradient on conductors – Bundle spacing and bundle radius –

Examples – Distribution of voltage gradient on sub conductors of bundle – Examples.

## **UNIT – II:**

### **Corona effects**

Power loss and audible noise (AN) – Corona loss formulae – Charge voltage diagram – Generation – Characteristics – Limits and measurements of AN – Relation between 1-phase and 3-phase AN levels – Examples – Radio interference (RI) – Corona pulses generation – Properties and limits – Frequency spectrum – Modes of propagation – Excitation function – Measurement of RI, RIV and excitation functions – Examples.

## **UNIT – III:**

### **Basic Concepts of DC Transmission**

Economics & Terminal equipment of HVDC transmission systems: Types of HVDC Links – Apparatus required for HVDC Systems – Comparison of AC & DC transmission – Application of DC Transmission System – Planning & Modern trends in DC transmission.

## **UNIT – IV:**

### **Analysis of HVDC Converters and System Control**

Choice of Converter configuration – Analysis of Graetz – Characteristics of 6 Pulse & 12 Pulse converters – Cases of two 3 phase converters in star – Star mode and their performance – Principal of DC Link Control – Converters Control Characteristics – Firing angle control – Current and extinction angle control – Effect of source inductance on the system – Starting and stopping of DC link – Power Control.

## **UNIT–V:**

### **Reactive Power Control in HVDC**

Reactive Power Requirements in steady state – Conventional control strategies – Alternate control strategies sources of reactive power – AC Filters – Shunt capacitors – Synchronous condensers.

## **UNIT – VI:**

### **Harmonics and Filters**

Generation of Harmonics – Characteristics harmonics – Calculation of AC Harmonics – Non-Characteristics harmonics – Adverse effects of harmonics – Calculation of voltage & current harmonics – Effect of Pulse number on harmonics. Types of AC filters, Design of Single tuned filters – Design of High pass filters.

**Learning Outcomes:**

- To be able to acquaint with HV transmission system with regard to power handling capacity, losses, conductor resistance and electrostatic field associate with HV. Further knowledge is gained in area of bundle conductor system to improve electrical and mechanical performance.
- To develop ability for determining corona, radio interference, audible noise generation and frequency spectrum for single and three phase transmission lines.
- To be able to acquire knowledge in transmission of HVDC power with regard to terminal equipments, type of HVDC connectivity and planning of HVDC system.
- To be able to develop knowledge with regard to choice of pulse conversion, control characteristic, firing angle control and effect of source impedance.
- To develop knowledge of reactive power requirements of conventional control, filters and reactive power compensation in AC. side of HVDC system.
- Able to calculate voltage and current harmonics, and design of filters for six and twelve pulse conversion.

**Text Books:**

1. HVDC Power Transmission Systems: Technology and system Interactions – by K.R.Padiyar, New Age International (P) Limited, and Publishers.
2. Direct Current Transmission – by E.W.Kimbark, John Wiley & Sons.
3. EHVAC Transmission Engineering by R. D. Begamudre, New Age International (P) Ltd.

**Reference Books:**

1. EHVAC and HVDC Transmission Engineering and Practice – S.Rao.
2. Power Transmission by Direct Current – by E.Uhlmann, B.S.Publications
3. HVDC Transmission – J. Arrillaga.

**IV Year – I SEMESTER**

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**POWER SYSTEM OPERATION AND CONTROL****Preamble:**

This subject deals with Economic operation of Power Systems, Hydrothermal scheduling and modeling of turbines, generators and automatic controllers. It emphasizes on single area and two area load frequency control and reactive power control.

**Learning Objectives:**

- To understand optimal dispatch of generation with and without losses.
- To study the optimal scheduling of hydro thermal systems.
- To study the optimal unit commitment problem.
- To study the load frequency control for single area system
- To study the PID controllers for single area system and two area system.
- To understand the reactive power control and compensation of transmission lines.

**UNIT-I:****Economic Operation of Power Systems**

Optimal operation of Generators in Thermal power stations, – Heat rate curve – Cost Curve – Incremental fuel and Production costs – Input–output characteristics – Optimum generation allocation with line losses neglected – Optimum generation allocation including the effect of transmission line losses – Loss Coefficients – General transmission line loss formula.

**UNIT-II:****Hydrothermal Scheduling**

Optimal scheduling of Hydrothermal System: Hydroelectric power plant models – Scheduling problems – Short term Hydrothermal scheduling problem.

**UNIT-III:****Unit Commitment**

Optimal unit commitment problem – Need for unit commitment – Constraints in unit commitment – Cost function formulation – Solution methods – Priority ordering – Dynamic programming.

**UNIT-IV:****Load Frequency Control**

Modeling of steam turbine – Generator – Mathematical modeling of speed governing system – Transfer function – Modeling of Hydro turbine – Necessity of keeping frequency constant – Definitions of Control area – Single area control – Block diagram representation of an isolated power system – Steady state analysis – Dynamic response – Uncontrolled case – Load frequency control of two area system – Uncontrolled case and controlled case – Tie-line bias control.

**UNIT-V:****Load Frequency Controllers**

Proportional plus Integral control of single area and its block diagram representation – Steady state response – Load Frequency Control and Economic dispatch control.

**UNIT-VI:****Reactive Power Control**

Overview of Reactive Power control – Reactive Power compensation in transmission systems – Advantages and disadvantages of different types of compensating equipment for transmission systems – Load compensation – Specifications of load compensator – Uncompensated and compensated transmission lines: Shunt and series compensation – Need for FACTS controllers.

**Learning Outcomes:**

- Able to compute optimal scheduling of Generators.
- Able to understand hydrothermal scheduling.
- Understand the unit commitment problem.
- Able to understand importance of the frequency.
- Understand importance of PID controllers in single area and two area systems.
- Will understand reactive power control and line power compensation.



**Text Books:**

1. Electric Energy systems Theory – by O.I.Elgerd, Tata McGraw–hill Publishing Company Ltd., Second edition.
2. Power System stability & control, Prabha Kundur, TMH
3. Modern Power System Analysis – by I.J.Nagrath & D.P.Kothari  
Tata Mc Graw – Hill Publishing Company Ltd, 2nd edition.

**Reference Books:**

1. Power System Analysis and Design by J.Duncan Glover and M.S.Sarma, THOMPSON, 3rd Edition.
2. Power System Analysis by Grainger and Stevenson, Tata McGraw Hill.
3. Power System Analysis by Hadi Saadat – TMH Edition.

**IV Year – I SEMESTER**

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**Open Elective****ENERGY AUDIT, CONSERVATION & MANAGEMENT****Preamble:**

This is an open elective course developed to cater current needs of the industry. This course covers topics such as energy conservation act and energy conservation. It also covers energy efficient lighting design, student will learn power factor improvement techniques, energy efficiency in HVAC systems. In addition, economic aspects such as payback period calculations, life cycle costing analysis is covered in this course.

**Learning Objectives:**

- To understand energy efficiency, scope, conservation and technologies.
- To design energy efficient lighting systems.
- To estimate/calculate power factor of systems and propose suitable compensation techniques.
- To understand energy conservation in HVAC systems.
- To calculate life cycle costing analysis and return on investment on energy efficient technologies.

**Unit-I:****Basic Principles of Energy Audit and management**

Energy audit – Definitions – Concept – Types of audit – Energy index – Cost index – Pie charts – Sankey diagrams – Load profiles – Energy conservation schemes and energy saving potential – Numerical problems – Principles of energy management – Initiating, planning, controlling, promoting, monitoring, reporting – Energy manager – Qualities and functions – Language – Questionnaire – Check list for top management.

**Unit-II:****Lighting**

Modification of existing systems – Replacement of existing systems – Priorities: Definition of terms and units – Luminous efficiency – Polar curve – Calculation of illumination level – Illumination of inclined surface to beam

– Luminance or brightness – Types of lamps – Types of lighting – Electric lighting fittings (luminaries) – Flood lighting – White light LED and conducting Polymers – Energy conservation measures.

### **Unit–III:**

#### **Power Factor and energy instruments**

Power factor – Methods of improvement – Location of capacitors – Power factor with non linear loads – Effect of harmonics on Power factor – Numerical problems. Energy Instruments – Watt-hour meter – Data loggers – Thermocouples – Pyrometers – Lux meters – Tong testers – Power analyzer.

### **Unit–IV:**

#### **Space Heating and Ventilation**

Ventilation – Air–Conditioning (HVAC) and Water Heating: Introduction – Heating of buildings – Transfer of Heat–Space heating methods – Ventilation and air–conditioning – Insulation–Cooling load – Electric water heating systems – Energy conservation methods.

### **Unit–V**

#### **Economic Aspects and Analysis**

Economics Analysis – Depreciation Methods – Time value of money – Rate of return – Present worth method – Replacement analysis – Life cycle costing analysis – Energy efficient motors (basic concepts).

### **Unit–VI:**

#### **Computation of Economic Aspects**

Calculation of simple payback method – Net present worth method – Power factor correction – Lighting – Applications of life cycle costing analysis – Return on investment.

### **Learning Outcomes:**

Student will be able to

- Explain energy efficiency, conservation and various technologies.
- Design energy efficient lighting systems.
- Calculate power factor of systems and propose suitable compensation techniques.
- Explain energy conservation in HVAC systems.
- Calculate life cycle costing analysis and return on investment on energy efficient technologies.

**Text Books:**

1. Energy management by W.R. Murphy & G. McKay Butterworth, Elsevier publications. 2012
2. Energy efficient electric motors by John C. Andreas, Marcel Dekker Inc Ltd–2<sup>nd</sup> edition, 1995

**Reference Books:**

1. Electric Energy Utilization and Conservation by S C Tripathy, Tata McGraw hill publishing company Ltd. New Delhi.
2. Energy management by Paul o' Callaghan, McGraw Hill Book company–1<sup>st</sup> edition, 1998.
3. Energy management hand book by W.C.Turner, John Wiley and sons.
4. Energy management and conservation –K V Sharma and P Venkata Seshaiah-I K International Publishing House Pvt.Ltd, 2011.
5. [http://www.energymanagertraining.com/download/Gazette\\_of\\_India\\_PartII\\_SecI-37\\_25-08-2010.pdf](http://www.energymanagertraining.com/download/Gazette_of_India_PartII_SecI-37_25-08-2010.pdf)

**Note :** This Elective can be offered to Students of All Branches including EEE.

## **INSTRUMENTATION**

### **(Open Elective)**

#### **Preamble:**

Electrical and Electronic Instrumentation plays a key role in the industry. With the advancement of technology day to day manual maintenance is replaced by simply monitoring using various instruments. Thus this course plays very important role in overall maintenance of the industry.

#### **Learning Objectives:**

- To study various types of signals and their representation.
- To study various types of transducers: Electrical, Mechanical, Electromechanical, Optical etc.
- To study and measure the various types of Non-electrical quantities.
- To study various types of digital voltmeters
- To study the working principles of various types of oscilloscopes and their applications.
- To study various types of signal analyzers.

#### **UNIT-I:**

##### **Signals and their representation**

Measuring Systems, Performance Characteristics, – Static characteristics – Dynamic Characteristics – Errors in Measurement – Gross Errors – Systematic Errors – Statistical analysis of random errors – Signal and their representation – Standard test, periodic, aperiodic, modulated signal – Sampled data pulse modulation and pulse code modulation.

#### **UNIT-II:**

##### **Transducers**

Definition of transducers – Classification of transducers – Advantages of Electrical transducers – Characteristics and choice of transducers – Principle operation of resistor, inductor, LVDT and capacitor transducers – LVDT Applications – Strain gauge and its principle of operation – Gauge factor – Thermistors – Thermocouples – Synchros – Piezo electric transducers – Photo diodes.

**UNIT-III:****Measurement of Non-Electrical Quantities**

Measurement of strain – Gauge Sensitivity – Displacement – Velocity – Angular Velocity – Acceleration – Force – Torque – Measurement of Temperature, Pressure, Vacuum, Flow, Liquid level.

**UNIT-IV:****Digital Voltmeters**

Digital voltmeters – Successive approximation, ramp, dual-Slope integration continuous balance type – Micro processor based ramp type – DVM digital frequency meter – Digital phase angle meter.

**UNIT-V:****Oscilloscope**

Cathode ray oscilloscope – Time base generator – Horizontal and vertical amplifiers – Measurement of phase and frequency – Lissajous patterns – Sampling oscilloscope – Analog and digital type data logger – Transient recorder.

**UNIT-VI:****Signal Analyzers**

Wave Analyzers – Frequency selective analyzers – Heterodyne – Application of Wave analyzers – Harmonic Analyzers – Total Harmonic distortion – Spectrum analyzers – Basic spectrum analyzers – Spectral displays – Vector impedance meter – Q meter – Peak reading and RMS voltmeters.

**Learning Outcomes:**

- Able to represent various types of signals .
- Acquire proper knowledge to use various types of Transducers.
- Able to monitor and measure various parameters such as strain, velocity, temperature, pressure etc.
- Acquire proper knowledge and working principle of various types of digital voltmeters.
- Able to measure various parameter like phase and frequency of a signal with the help of CRO.
- Acquire proper knowledge and able to handle various types of signal analyzers.

**Text Books:**

1. Electronic Instrumentation–by H.S.Kalsi Tata McGraw–Hill Edition, 1995.
2. A course in Electrical and Electronic Measurements and Instrumentation, A.K. Sawhney, Dhanpatrai & Co.

**Reference Books:**

1. Measurement and Instrumentation theory and application, Alan S.Morris and Reza Langari, Elsevier
2. Measurements Systems, Applications and Design – by D O Doebelin
3. Principles of Measurement and Instrumentation – by A.S Morris, Pearson / Prentice Hall of India
4. Modern Electronic Instrumentation and Measurement techniques – by A.D Helfrick and W.D. Cooper, Pearson/Prentice Hall of India.
4. Transducers and Instrumentation by D.V.S Murthy, Prentice Hall of India.

**Note :** This Elective can be offered to Students of All Branches including EEE.

## **NON-CONVENTIONAL SOURCES OF ENERGY**

### **(Open Elective)**

#### **Preamble:**

This course gives a flavor of non-conventional sources of energy to the students. It introduces solar energy its radiation, collection, storage and its applications. This covers generation, design, efficiency and characteristics of various non-conventional energy sources including solar, wind, hydro, biomass, fuel cells and geothermal systems.

#### **Learning Objectives**

- To study the solar radiation data, extraterrestrial radiation, radiation on earth's surface.
- To study solar thermal collections.
- To study solar photo voltaic systems.
- To study maximum power point techniques in solar pv and wind.
- To study wind energy conversion systems, Betz coefficient , tip speed ratio.
- To study basic principle and working of hydro, tidal, biomass, fuel cell and geothermal systems.

#### **UNIT-I:**

##### **Fundamentals of Energy Systems**

Energy conservation principle – Energy scenario (world and India) – Solar radiation: Outside earth's atmosphere – Earth surface – Analysis of solar radiation data – Geometry – Radiation on tilted surfaces – Numerical problems.

#### **UNIT-II:**

##### **Solar Thermal Systems**

Liquid flat plate collections: Performance analysis – Transmissivity – Absorptivity – Product collector efficiency factor – Collector heat removal factor – Numerical problems – Introduction to solar air heaters – Concentrating collectors and solar pond.

#### **UNIT-III:**

##### **Solar Photovoltaic Systems**

Balance of systems – IV characteristics – System design: Storage sizing, PV system sizing, Maximum power point techniques: Perturb and observe (P&O) technique – Hill climbing technique.



**UNIT-IV:****Wind Energy**

Wind patterns – Types of turbines – Kinetic energy of wind – Betz coefficient – Tip-speed ratio – efficiency – Power output of wind turbine – Selection of generator(synchronous, induction) – Maximum power point tracking.

**UNIT-V:****Hydro and Tidal power systems**

Basic working principle – Classification of hydro systems: large, small, micro – Measurement of head and flow – Energy equation – Types of turbines – Numerical problems.

Tidal power – Basics – Kinetic energy equation – Numerical problems – Wave power – Basics – Kinetic energy equation.

**UNIT-VI:****Biomass, fuel cells and geothermal systems**

Biomass Energy: Fuel classification – Pyrolysis – Direct combustion of heat – Different digesters and sizing.

Fuel cell: classification – Efficiency – VI characteristics.

Geothermal: classification – Dry rock and aquifer – Energy analysis.

**Learning Outcomes:**

Student should be able to

- Analyze solar radiation data, extraterrestrial radiation, radiation on earth's surface.
- Design solar thermal collections.
- Design solar photo voltaic systems.
- Develop maximum power point techniques in solar PV and wind.
- Explain wind energy conversion systems, Betz coefficient , tip speed ratio.
- Explain basic principle and working of hydro, tidal, biomass ,fuel cell and geothermal systems.

**Text Books:**

1. Solar Energy: Principles of Thermal Collection and Storage, S. P. Sukhatme and J. K. Nayak, TMH, New Delhi, 3<sup>rd</sup> Edition.
2. Renewable Energy Resources, John Twidell and Tony Weir, Taylor and Francis.

3. Energy Science: Principles, Technologies and Impacts, John Andrews and Nick Jelly, Oxford.

**Reference Books:**

1. Handbook of renewable technology Ahmed and Zobaa, Ramesh C Bansal, World scientific, Singapore.
2. Renewable Energy Technologies /Ramesh & Kumar /Narosa.
3. Renewable energy technologies – A practical guide for beginners – Chetong Singh Solanki, PHI.

**Note :** This Elective can be offered to Students of All Branches including EEE.

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## **OPTIMIZATION TECHNIQUES**

### **(Open Elective)**

#### **Preamble:**

Optimization techniques have gained importance to solve many engineering design problems by developing linear and nonlinear mathematical models. The aim of this course is to educate the student to develop a mathematical model by defining an objective function and constraints in terms of design variables and then apply a particular mathematical programming technique. This course covers classical optimization techniques, linear programming, nonlinear programming and dynamic programming techniques.

#### **Learning Objectives:**

1. To define an objective function and constraint functions in terms of design variables, and then state the optimization problem.
2. To state single variable and multi variable optimization problems, without and with constraints.
3. To explain linear programming technique to an optimization problem, define slack and surplus variables, by using Simplex method.
4. To state transportation and assignment problem as a linear programming problem to determine optimality conditions by using Simplex method.
5. To study and explain nonlinear programming techniques, unconstrained or constrained, and define exterior and interior penalty functions for optimization problems.
6. To explain Dynamic programming technique as a powerful tool for making a sequence of interrelated decisions.

#### **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.

#### **UNIT – II:**

##### **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 – III:**

#### **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 - Duality in Linear Programming – Dual Simplex method.

### **UNIT – IV:**

#### **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 – Special cases in transportation problem.

### **UNIT – V:**

#### **Nonlinear Programming:**

**Unconstrained cases** - One – dimensional minimization methods: Classification, Fibonacci method and Quadratic interpolation method - Univariate method, Powell's method and steepest descent method.

**Constrained cases** - Characteristics of a constrained problem, Classification, Basic approach of Penalty Function method; Basic approaches of Interior and Exterior penalty function methods. Introduction to convex Programming Problem.

### **UNIT – VI:**

#### **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.

#### **Learning Outcomes:**

The student should be able to:

1. State and formulate the optimization problem, without and with constraints, by using design variables from an engineering design problem.

2. Apply classical optimization techniques to minimize or maximize a multi-variable objective function, without or with constraints, and arrive at an optimal solution.
3. Formulate a mathematical model and apply linear programming technique by using Simplex method. Also extend the concept of dual Simplex method for optimal solutions.
4. Solve transportation and assignment problem by using Linear programming Simplex method.
5. Apply gradient and non-gradient methods to nonlinear optimization problems and use interior or exterior penalty functions for the constraints to derive the optimal solutions.
6. Formulate and apply Dynamic programming technique to inventory control, production planning, engineering design problems etc. to reach a final optimal solution from the current optimal 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.

**Reference Books:**

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

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**Note :** This Elective can be offered to Students of All Branches except EEE.

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**Elective – I****VLSI DESIGN****Preamble:**

In the recent times fabrication technology is revolutionized and especially LSI has become so dense that on a single IC tens and thousands of transistors are placed. Thus integrated circuits have become integrated systems and the development of fabrication technology VLSI plays very important role.

**Learning Objectives:**

- To provide the basic fundamentals of fabrication technology, generations of IC and speed, power consumptions of various fabrication technologies.
- To understand the knowledge of electrical properties of MOS circuits.
- To learn the design concepts of stick diagrams, layouts for various MOS technologies.
- To understand the concepts of design rules, scaling, subsystem design semiconductor IC design.
- To understand the synthesis, simulation design verification tools, CMOS testing.

**UNIT –I****Introduction**

Introduction to IC technology – The IC era – MOS and related VLSI technology – Basic MOS transistors – Enhancement and depletion modes of transistor action – IC production process – MOS and CMOS fabrication process – BiCMOS technology – Comparison b/w CMOS and bipolar technologies.

**UNIT – II****Basic electrical properties of MOS and BiCMOS circuits**

$I_{ds}$ – $V_{ds}$  relationships – Aspects of MOS transistor threshold voltage – MOS Trans-conductance and output conductance – MOS Transistor – Figure of merit – The pMOS transistor – The nMOS inverter – Determination of pull-up to pull-down ratio for nMOS inverter driven by another nMOS inverter

for an nMOS inverter driven through one or more pass Transistors – Alternative forms of pull up – The CMOS Inverter MOS transistor Circuit model – Bi-CMOS Inverters.

### **UNIT – III**

#### **MOS and BiCOMS circuit design processes**

MOS layers – Stick diagrams – Design rules and layout – General observation on the design rules,  $2\mu\text{m}$  double metal, double poly – CMOS/BiCMOS rules,  $1.2\mu\text{m}$  Double metal, Double poly CMOS rules – Layout diagrams of NAND and NOR gates and CMOS inverter – Symbolic Diagrams – Translation to Mask Form.

### **UNIT – IV**

#### **Basic circuit concepts**

Sheet resistance – Sheet resistance concept applied to MOS transistor and inverters – Area capacitance of layers – Standard unit of capacitance – Some area capacitance calculations – The delay unit – Inverter delays – Driving large capacitive loads – Propagations Delays – Wiring Capacitance – Fan-in and Fan-out characteristics – Choice of layers – Transistor switches – Realization of gates using nMOS, pMOS and CMOS technologies.

### **UNIT – V**

#### **Scaling of MOS circuit**

Scaling models and scaling factors – Scaling factors for device parameters – Limitations of scaling – Limits due to sub threshold currents – Limits on logic level and supply voltage due to noise – Limits due to current density – Some architectural Issues – Introduction to switch logic and gate logic.

### **UNIT – VI**

#### **Digital design using HDL**

Digital system design process – VLSI Circuit Design Process – Hardware simulation – Hardware Synthesis – History of VHDL – VHDL requirements – Levels of abstraction – Elements of VHDL – Packages – Libraries and bindings – Objects and classes – Variable assignments – Sequential statements – Usage of subprograms – Comparison of VHDL and verilog HDL.

### **VHDL MODELLING**

Simulation – Logic Synthesis – Inside a logic synthesizer – Constraints – Technology libraries – VHDL and logic synthesis – Functional gate – Level verification – Place and route – Post layout timing simulation – Static timing

– Major net list formats for design representation – VHDL synthesis – Programming approach.

### **Learning Outcomes**

- Ability to demonstrate the fundamentals of IC technology such as various MOS fabrication technologies.
- Ability to calculate electrical properties of MOS circuits such as  $I_{ds}$  –  $V_{ds}$  relationship,  $V_t$ ,  $\mu_n$ ,  $\mu_p$ ,  $\tau_n$ ,  $\tau_p$ , figure of merit, sheet resistance, area capacitance.
- Ability to demonstrate semi conductor IC design such as PLA's, PAL, FPGA, CPLD's design.
- Ability to demonstrate VHDL synthesis, simulation, design capture tools design verification tools, CMOS testing.

### **Text Books:**

1. Essentials of VLSI Circuits and Systems–Kamran Eshraghian, Douglas and A.Pucknell and Sholeh Eshraghian, Prentice–Hall of India Private Limited, 2005 Edition.
2. VLSI Design–K. Lal Kishor and V.S.V.Prabhakar, I.K. International Publishing House Private Limited, 2009 First Edition.
3. VLSI Design–A.Shanthi and A.Kavitha, New Age International Private Limited, 2006 First Edition.

### **References Books:**

1. VLSI Design By Debaprasad Das, Oxford University Press, 2010.
2. VLSI Design By A.Albert Raj & T. Latha, PHI Learning Private Limited, 2010.



## **ELECTRICAL DISTRIBUTION SYSTEMS (ELECTIVE–I)**

### **Preamble:**

This subject deals with the general concept of distribution system, substations and feeders as well as discusses distribution system analysis, protection and coordination, voltage control and power factor improvement.

### **Learning Objectives**

- To study different factors of Distribution system.
- To study and design the substations and distribution systems.
- To study the determination of voltage drop and power loss.
- To study the distribution system protection and its coordination.
- To study the effect of compensation on p.f improvement.
- To study the effect of voltage control on distribution system.

### **UNIT – I:**

#### **General Concepts**

Introduction to distribution systems, Load modeling and characteristics – Coincidence factor – Contribution factor loss factor – Relationship between the load factor and loss factor – Classification of loads (Residential, commercial, Agricultural and Industrial) and their characteristics.

### **UNIT – II:**

#### **Substations**

Location of substations: Rating of distribution substation – Service area within primary feeders – Benefits derived through optimal location of substations.

#### **Distribution Feeders**

Design Considerations of distribution feeders: Radial and loop types of primary feeders – Voltage levels – Feeder loading – Basic design practice of the secondary distribution system.

### **UNIT – III:**

#### **System Analysis**

Voltage drop and power-loss calculations: Derivation for voltage drop and power loss in lines – Manual methods of solution for radial networks – Three phase balanced primary lines.

**UNIT – IV:****Protection**

Objectives of distribution system protection – Types of common faults and procedure for fault calculations – Protective devices: Principle of operation of fuses – Circuit reclosures – Line sectionalizers and circuit breakers.

**Coordination**

Coordination of protective devices: General coordination procedure – Residual current circuit breaker RCCB (Wikipedia).

**UNIT – V:****Compensation for Power Factor Improvement**

Capacitive compensation for power-factor control – Different types of power capacitors – shunt and series capacitors – Effect of shunt capacitors (Fixed and switched) – Power factor correction – Capacitor allocation – Economic justification – Procedure to determine the best capacitor location.

**UNIT – VI:****Voltage Control**

Voltage Control: Equipment for voltage control – Effect of series capacitors – Effect of AVB/AVR –Line drop compensation.

**Learning Outcomes:**

- Able to understand the various factors of distribution system.
- Able to design the substation and feeders.
- Able to determine the voltage drop and power loss
- Able to understand the protection and its coordination.
- Able to understand the effect of compensation on p.f improvement.
- Able to understand the effect of voltage, current distribution system performance.

**Text Book:**

1. “Electric Power Distribution system, Engineering” – by TuranGonen, McGraw–hill Book Company.

**Reference Books:**

1. Electrical Distribution Systems by Dale R.Patrick and Stephen W.Fardo, CRC press
2. Electric Power Distribution – by A.S. Pabla, Tata McGraw–hill Publishing company, 4<sup>th</sup> edition, 1997.
3. Electrical Power Distribution Systems by V.Kamaraju, Right Publishers.

## **OPTIMIZATION TECHNIQUES**

### **(Elective-I)**

#### **Preamble:**

Optimization techniques have gained importance to solve many engineering design problems by developing linear and nonlinear mathematical models. The aim of this course is to educate the student to develop a mathematical model by defining an objective function and constraints in terms of design variables and then apply a particular mathematical programming technique. This course covers classical optimization techniques, linear programming, nonlinear programming and dynamic programming techniques.

#### **Learning Objectives:**

1. To define an objective function and constraint functions in terms of design variables, and then state the optimization problem.
2. To state single variable and multi variable optimization problems, without and with constraints.
3. To explain linear programming technique to an optimization problem, define slack and surplus variables, by using Simplex method.
4. To state transportation and assignment problem as a linear programming problem to determine optimality conditions by using Simplex method.
5. To study and explain nonlinear programming techniques, unconstrained or constrained, and define exterior and interior penalty functions for optimization problems.
6. To explain Dynamic programming technique as a powerful tool for making a sequence of interrelated decisions.

#### **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.

#### **UNIT – II:**

##### **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 – III:**

#### **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 - Duality in Linear Programming – Dual Simplex method.

### **UNIT – IV:**

#### **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 – Special cases in transportation problem.

### **UNIT – V:**

#### **Nonlinear Programming:**

**Unconstrained cases** - One – dimensional minimization methods: Classification, Fibonacci method and Quadratic interpolation method - Univariate method, Powell's method and steepest descent method.

**Constrained cases** - Characteristics of a constrained problem, Classification, Basic approach of Penalty Function method; Basic approaches of Interior and Exterior penalty function methods. Introduction to convex Programming Problem.

### **UNIT – VI:**

#### **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.

#### **Learning Outcomes:**

The student should be able to:

1. State and formulate the optimization problem, without and with constraints, by using design variables from an engineering design problem.

2. Apply classical optimization techniques to minimize or maximize a multi-variable objective function, without or with constraints, and arrive at an optimal solution.
3. Formulate a mathematical model and apply linear programming technique by using Simplex method. Also extend the concept of dual Simplex method for optimal solutions.
4. Solve transportation and assignment problem by using Linear programming Simplex method.
5. Apply gradient and non-gradient methods to nonlinear optimization problems and use interior or exterior penalty functions for the constraints to derive the optimal solutions.
6. Formulate and apply Dynamic programming technique to inventory control, production planning, engineering design problems etc. to reach a final optimal solution from the current optimal 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.

**Reference Books:**

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

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**IV Year – I SEMESTER**

T	P	C
0	3	2

**MICROPROCESSORS AND  
MICROCONTROLLERS LAB****Learning Objectives:**

- To study programming based on 8086 microprocessor and 8051 microcontroller.
- To study 8056 microprocessor based ALP using arithmetic, logical and shift operations.
- To study modular and Dos/Bios programming using 8086 micro processor.
- To study to interface 8086 with I/O and other devices.
- To study parallel and serial communication using 8051 micro controller.

**Any 8 of the following experiments are to be conducted :**

**I. Microprocessor 8086 :**

Introduction to MASM/TASM.

1. Arithmetic operation – Multi byte addition and subtraction, multiplication and division – Signed and unsigned arithmetic operation, ASCII – Arithmetic operation.
2. Logic operations – Shift and rotate – Converting packed BCD to unpacked BCD, BCD to ASCII conversion.
3. By using string operation and Instruction prefix: Move block, Reverse string Sorting, Inserting, Deleting, Length of the string, String comparison.
4. Modular Program: Procedure, Near and Far implementation, Recursion.
5. Dos/BIOS programming: Reading keyboard (Buffered with and without echo) – Display characters, Strings.
6. Interfacing 8255–PPI
7. Programs using special instructions like swap, bit/byte, set/reset etc.
8. Programs based on short, page, absolute addressing.
9. Interfacing 8259 – Interrupt Controller.

10. Interfacing 8279 – Keyboard Display.
11. Stepper motor control using 8253/8255.

Any 2 of the following experiments are to be conducted:

### **Microcontroller 8051**

12. Reading and Writing on a parallel port.
13. Timer in different modes.
14. Serial communication implementation.
15. Understanding three memory areas of 00 – FF (Programs using above areas).  
Using external interrupts.

### **Learning Outcomes:**

- Will be able to write assembly language program using 8086 micro based on arithmetic, logical, and shift operations.
- Will be able to do modular and Dos/Bios programming using 8086 micro processor.
- Will be able to interface 8086 with I/O and other devices.
- Will be able to do parallel and serial communication using 8051 micro controllers.

**IV Year – I SEMESTER**

<b>T</b>	<b>P</b>	<b>C</b>
<b>0</b>	<b>3</b>	<b>2</b>

**ELECTRICAL SIMULATION LAB****Learning objectives:**

- To simulate integrator circuit, differentiator circuit, Boost converter, Buck converter, full convertor and PWM inverter.
- To simulate transmission line by incorporating line, load and transformer models.
- To perform transient analysis of RLC circuit and single machine connected to infinite bus (SMIB).
- To find load flow solution for a transmission network with Newton–Rampson method.

**Following experiments are to be conducted:**

1. Simulation of transient response of RLC circuits
  - a. Response to pulse input
  - b. Response to step input
  - c. Response to sinusoidal input
2. Analysis of three phase circuit representing the generator transmission line and load. Plot three phase currents & neutral current.
3. Simulation of single–phase full converter using RLE loads and single phase AC voltage controller using RL loads.
4. Plotting of Bode plots, root locus and nyquist plots for the transfer functions of systems up to 5<sup>th</sup> order.
5. Power system load flow using Newton–Raphson technique.
6. Simulation of Boost and Buck converters.
7. Integrator & Differentiator circuits using op–amp.
8. Simulation of D.C separately excited motor using transfer function approach.

**Any 2 of the following experiments are to be conducted:**

1. Modeling of transformer and simulation of lossy transmission line.
2. Simulation of single phase inverter with PWM control.
3. Simulation of three phase full converter using MOSFET and IGBTs.
4. Transient analysis of single machine connected to infinite bus (SMIB).



**Learning outcomes:**

- Able to simulate integrator circuit, differentiator circuit, Boost converter, Buck converter, full convertor and PWM inverter.
- Able to simulate transmission line by incorporating line, load and transformer models.
- Able to perform transient analysis of RLC circuit and single machine connected to infinite bus (SMIB).
- Able to find load flow solution for a transmission network with Newton–Rampson method.

**Reference Books:**

1. “Simulation of Power Electronic Circuit“, by M.B. Patil, V.Ramanarayan, V.T. Ranganathan. Narosha, 2009.
2. Pspice for circuits and electronics using PSPICE – by M.H.Rashid, M/s PHI Publications.
3. Pspice A/D user`s manual – Microsim, USA.
4. Pspice reference guide – Microsim, USA.
5. MATLAB user`s manual – Mathworks, USA.
6. MATLAB – control system tool box – Mathworks, USA.
7. SIMULINK user`s manual – Mathworks, USA.
8. EMTP User`s Manual.
9. SEQUEL– A public domain circuit simulator available at [www.ee.iitb.ac.in/~sequel](http://www.ee.iitb.ac.in/~sequel).

**IV Year – I SEMESTER**

<b>T</b>	<b>P</b>	<b>C</b>
<b>0</b>	<b>3</b>	<b>2</b>

**POWER SYSTEMS LAB****Learning Objectives:**

To impart the practical knowledge of functioning of various power system components and determination of various parameters and simulation of load flows, transient stability, LFC and Economic dispatch.

**Any 10 of the Following experiments are to be conducted:**

1. Sequence impedances of 3 phase Transformer.
2. Sequence impedances of 3 phase Alternator by Fault Analysis.
3. Sequence impedances of 3 phase Alternator by Direct method.
4. ABCD parameters of Transmission network.
5. Power Angle Characteristics of 3phase Alternator with infinite bus bars.
6. Dielectric strength of Transformer oil.
7. Calibration of Tong Tester.
- 8&9. Load flow studies any two methods.
10. Transient Stability Analysis
11. Load frequency control without control
12. Load frequency control with control
13. Economic load dispatch without losses
14. Economic load dispatch with losses.

**Learning Outcomes:**

The student is able to determine the parameters of various power system components which are frequently occur in power system studies and he can execute energy management systems functions at load dispatch centre.