# Biju Patnaik University of Technology, Orissa

## Course for M.Tech. Syllabus

### (1st Sem, Power System Engineering/Electrical Engineering)

# M.Tech (Power System Engineering)

**Sem – I**

| | | |
|---|---|---|
| Professional Core | : | PC- 1 Power System Analysis |
| | | PC- 2 Power Apparatus and Systems |
| | | PC- 3 EHVAC Transmission. |
| Electives | : | EL- 1 a) Advanced Power Electronics |
| | | OR |
| | | b) Protection & Digital Relaying |
| | | EL- 2 a) Optimization Techniques |
| | | OR |
| | | b) Power Quality. |
| Sessional | : | SE- 1 : Power System Lab – I |
| Seminar | : | Seminar-1 : Pre Thesis Work related Seminar |

**Sem – II**

| | | |
|---|---|---|
| Professional Core | : | PC- 4 Power System Transients. |
| | | PC- 5 Power System Dynamics |
| Electives | : | EL- 3 a) HVDC & Facts Devices. |
| | | OR |
| | | b) Power System Management |
| | | EL- 4 a) Advanced DSP |
| | | OR |
| | | b) Advanced Control Systems. |
| | | EL- 5 a) AC and DC Drives |
| | | OR |
| | | b) Power System Reliability. |
| Sessional | : | SE- 2 : Power System Lab – II |
| Seminar | : | Seminar-2 : Pre Thesis Work related Seminar. |
| Comp. Viva Voce | : | Viva Voce- 1 |

**Sem – III**

| | | |
|---|---|---|
| Open Electives | : | OE a) Soft Computing Application. |
| | | OR |
| | | b) Project Management |
| | | OR |
| | | c) Energy Management |
| | | OR |
| | | b) Project Management Process Control & Instrumentation |
| Thesis-Part-I | : | TH – I |

**Sem- IV**

| | | |
|---|---|---|
| Thesis-Part-II | : | TH – II |
| Seminar | : | Seminar-3 |
| Comp. Viva Voce | : | Viva Voce- 2 |

# PC- 1 Power System Analysis

**Module- I**

Automatic Generation and Voltage Control:

Turbine & Generator- Load frequency Scheme, Steady state & dynamic analysis in frequency domain for single & two area system, Economic dispatch Control, Automatic Voltage Control. Power flow Analysis- NR and Fast Decoupled methods.

**Module- II**

Optimal System Operation:

Generation allocation problem formulation, Loss Coefficients, Optimal load flow solution, Hydrothermal Coordination, constraints in Unit- commitment, Unit commitment solution methods.

**Module- III**

Modeling of Transmission lines & transformers with off-nominal taps.

Sparse matrise technique for large- Scale system problems- Gaues elimination & bi-factorization method. Algorithm for short circuit studies, Z Bus Fomulation, Unsymmetrical fault analysis using symmetrical components.

*Books Recommended:*


1. *Stagg G.W., Eabiad A.H. " Computer methods in Power system analysis." Mc Graw Hill, 1968.*
2. *Nagrath & Kothari, "Modern Power System Analysis"*
3. *Elaerd O.Z, " Electrical Energy System Theory- An*

# PC-2 POWER APPARATUS AND SYSTEMS

**Module-I** **(12 Hrs)**

**Synchronous Machines:** The basis of General Theory and Generalized Equation of A.C machines, Equation in terms of phases variable park's transformation, Various reference frames, Derivation of two-axis equation, Torque equation, Field and damper windings, Equivalent circuits, Operational impedances and frequency response loci, Modified equation with more accurate coupling between field and damper windings.

**Selected topics on prime mover and energy supply systems:** Governors for hydraulic and steam turbines, Transient droop, speed governing system.

**Module-II** **(12 Hrs)**

**Synchronous Generator short circuit and system faults:** Symmetrical short circuit of unloaded generator, Analysis of short circuit oscillograms, short circuit of loaded synchronous generator, Unsymmetrical short of synchronous generator, system fault calculation, Sudden load changes, Equivalent circuit under transient condition, Constant flux linkage theorem, Simplified phasor diagram for transient changes.

**Selected topics on excitation systems:** Modeling of excitation system components, exciter (D.C and A.C), Amplifier, Stabilizing circuit

**Module-III** **(12 Hrs)**

**Induction machines:** Generator equation of the induction motor (equation), Application of equation in primary and secondary reference frames and complex form of equation, Short circuit and fault current due to the induction motor, fault calculation.

**Transformers:** Transient phenomena in transformer and transformer protection: General characteristics of over voltage and current inrush, Transient over voltage characteristics tics, Ferro resonant over voltage, protection against surges and insulation co-ordination.

***BOOKS RECOMMENDED :***


1. *The Generalized theory of electrical machines (Chapters: 1,2,34,5,8 and 11 by B.Adkins and R.H. Hiiley.*
2. *Principle, Operation and Design of power Transformer By S.B Vasciitnsky.*
3. *The J & P transformer Book (Chapter: 22&23) By S. Austen Stigant and A.C Franklin.*
4. *Power System Stability & Control ( Chapters: 8&9) By P.Kundur, McGraw Hill-1994.*

# PC- 3 EHVAC Transmissions

**Module- I (10 hrs)**

**Introduction to EHV Transmission Comparison of AC and DC Transmission Systems.** Parameters of EHV Lines:- Resistance of conductors, bundle conductors, Inductance of EHV Line configurations line capacitance, Sequence Inductance and capacitance, Line parameters for modes of propagation, resistance and Inductance of Ground returns.

**Module- II (10 hrs)**

Voltage Gradient of conductors:- Field of sphere gap, field of line charges and their properties. Charge – potential relations for multi-conductor lines surface voltage gradient and conductors without and with ground wires consideration, gradient factors, Distribution of voltage gradient on sub-conductors of bundle.

**Module- III (10 hrs)**

**Corona effects- I :** Power loss and Audible Noise Corona loss, Charge- Voltage diagram. Attenuation of traveling waves Audible.
Noise: Generation, Characteristics and its limitation, Measurement, meters, 1-phase and 3-phase AN levels, Day-Night equivalent Noise level.

**Power frequency voltage control and over-voltage:-** Generalised constants, Cascade connection of components-shunt and series compensation. Sub-synchronous Resonance in series- capacitor compensated lines, Static Reactive compensating systems.

**Module – IV (10 hrs)**

Over voltage in EHV systems caused by switching operations:-
Origin of over voltage and their types, short circuit current and circuit breaker. Recovery voltage and the circuit breaker, Over voltage caused by interruption of inductive current, Interruption of capacitive currents, Ferro resonance over voltage, calculation of switching surges single phase equivalents, distributed parameter line energized by source, generalized equations for single phase representation, Generalised equation of three phase systems, inverse Fourier transform for the general case, Reduction of switching surges on EHV systems, Experimental and calculated results of switching surge studies.

***Books:-***

1. *Begamudre R.D., "Extra High Voltage A.C. Transmission" Mc Graw Hill 1968.*

# Advanced Power Electronics

**Model-I**

1-Φ and 3-ф Controlled rectifiers-Average output voltages and currents for R-L. load performance parameters of rectifier 1- ф and 3- ф converter.
DC-DC converters: Buck, Boost, Buck-boost and Cuk converters, linear power supplies.
Switch mode DC Power supplies, Fly back converter, Forward converter, push pull converter , half bridge and full bridge converter.

**Module-II**

Basic concepts of switch mode inverter, pulse width modulated switching scheme , unipolar and bipolar Switching scheme, 1-ф inverters, push pull inverters, 3-ф inverters, PWM in 3-ф voltage source inverters. Reduction of Harmonies , square-wave pulse switching, programmed Harmonic elimination switching.

**Module-III**

Resonant pulse Converters: Classification of resonant Converters, series Resonant Inverter: Series Resonant inverters with unidirectional switches, series resonant inverters with bi-directional switches. Parallel Resonant Inverters, Zero current switching resonant converters, zero voltage switching resonant converters.

**Books for Reference**


1. Power electronics, Circuits, devices. Application by M.H.Rashid (PHI)
2. Power electronics, converters ., applications and Design N.Mohan undeland and Robbins John wily and sons inc.
3. Modern Power electronics and AC Drives by B.K .Bose.

# PROTECTION AND DEGITAL RELAYING

**Module-I**

Protection Schemes and Characteristics: Primary and back up protection , current transformers for protection , potential transformer, review of electromagnetic relays static relays , over current relays time current characteristic, current setting time setting, directional relay, static over current relays.
Distance protection: impedance, reactance, mho, angle impedance relays. Input quantities for various types of distance relays, effect of arc resistance on the performance of distance relays, selection of distance relays. MHO relay with blinders, quadrilateral relay , elliptical relay. Restricted mho, impedance directional, reactance relays, swiveling characteristics.

**Module-II**

**Compensation Schemes:** Compensation for correct distance measurement , reduction of measuring units switched schemes. Pilot relaying schemes. Wire pilot protection , circulating current scheme, balanced voltage scheme, transley scheme, carrier current protection , phase comparison carrier current protection, carrier aided distance protection.

**Module-III**

**Digital Relaying:** Digital relaying algorithms, differential equation technique, discrete Fourier transform technique, walsh-hadamard transform technique, rationalized harr transform technique, removal of dc offset.
**Microprocessor based protective relays:** over current , directional, impedance, reactance relays. Generalized mathematical expressions for distance relays, mho and offset mho relays, quadrilateral relay, microprocessor implementation of digital distance relaying algorithms.

Text book

1. Power system protection and switchgear by Badri ram and vishwkrama, TMH publication New Delhi 1995.
2. power system protection by Madhava Rao TMH

**Reference Books**

1. Power system by Ravindra Nath and chandar PHI.

# Optimization Techniques

**Module-I**

**Optimization Fundamentals:**
Definition , classification of optimization problems, Unconstrained and constrained optimization, optimality conditions.

**Linear Programming:**
Simplex Method, Duality, Sensitivity methods.

**Module-II**

**Nonlinear Programming:**

Powel's method, steepest descent method, conjugates gradient method, Newton's Method GRG method, Sequential quadratic programming, Penalty function method, Augmented Lagrange multiplier method.

Dynamic Programming and Integer Programming
Interior point methods
Karmakar's algorithm , Dual affine, Primal affine , Barrie algorithm.

**Module-III**

Simulated annealing , Evolutionary Programming , Genetic algorithm and Genetic Engineering.
Finite Element Based Optimization.

**Reference Books**


1. Ashok D.belegundu and Chrandrapatla T. R " Optimization Concept and Application in Engineering " Prentice Hall, 1999.
2. Rao S.S " Engineering Optimization"
3. Gill , Murray and Wright ," Practical Optimization"
4. James A. Memoh." Electic Power System Application of optimization."
5. song Y. , "Modern Optimization Techniques in power System"

# POWER QUALITY

**Module-I**

**Introduction:** power quality (PQ) problem, Voltage sag, Swell , Surges, Harmonic, over voltages, spikes, Voltage fluctuations, Transients, interruption overview of power quality phenomenon , Remedies to improve power quality, power quality monitoring.

**Interruptions:** Definition, Difference between failure, outage, causes and 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.

**Module-II**

**Voltage Sag:** Characterization of voltage sag , definition, causes of voltage sag , voltage sag magnitude , monitoring, theoretical calculation of voltage sag magnitude , voltage sag calculation in non-radial systems, meshed systems, voltage sag duration.

**PQ considerations in Industrial Power Systems:** voltage sag effects, 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 drive and its operation, mitigation methods of DC drives.

**Module-III**

**Mitigation of Interruptions and Voltage Sags:** Overview of mitigation methods- form 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.

**Reference Book:**

1. " Understanding Power Quality Problems" by Math H J Bollen, IEEE Press.
2. Electrical power quality –R C Dugan, M.F,M Granghar, H.W.Beaty-TMH.