## JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
## M. TECH. (ELECRICAL POWER SYSTEMS/POWER ENGINEERING AND ENERGY SYSTEMS/ POWER SYSTEM CONTROL AND AUTOMATION/ ELECRICAL POWER ENGINEERING)
## COURSE STRUCTURE AND SYLLABUS

**I Year – II Semester**

| Category | Course Title | Int. marks | Ext. marks | L | P | C |
|---|---|---|---|---|---|---|
| Core Course IV | Power System Dynamics | 25 | 75 | 4 | -- | 4 |
| Core Course V | Flexible AC Transmission Systems (FACTS) | 25 | 75 | 4 | -- | 4 |
| Core Course VI | Power System Operation and Deregulation | 25 | 75 | 4 | -- | 4 |
| Core Elective III | 1. Gas Insulated Systems(GIS)<br>2. Programmable Logic Controllers and their applications<br>3. High frequency magnetic components | 25 | 75 | 4 | -- | 4 |
| Core Elective IV | 1. Reactive Power Compensation and Management<br>2. Power System Reliability<br>3. Voltage Stability | 25 | 75 | 4 | -- | 4 |
| Open Elective II | 1. Instrumentation & Control<br>2. Intelligent Control<br>3. Smart grid technologies<br>4. AI Techniques in Electrical Engineering<br>5. Reliability Engineering<br>6. Energy Auditing, Conservation & Management | 25 | 75 | 4 | -- | 4 |
| Laboratory II | Power Systems Lab-II | 25 | 75 | -- | 4 | 2 |
| Seminar II | Seminar-II | 50 | -- | -- | 4 | 2 |
| **Total Credits** | | | | **24** | **8** | **28** |

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# POWER SYSTEM DYNAMICS

**Prerequisite: Computer Methods in Power Systems**
**Course objectives:**

- To remember the dynamic characteristics of power system equipment,
- To recognize dynamic performance of power systems
- To illustrate the system stability and controls.

**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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## FLEXIBLE AC TRANSMISSION SYSTEMS (FACTS)

**Prerequisite: Power Electronics and Power Systems-II**
**Course Objectives:**

- To understand the fundamentals of FACTS Controllers, Importance of controllable parameters and types of FACTS controllers & their benefits
- To recall the oobjectives of Shunt and Series compensation
- To explain ccontrol of STATCOM and SVC and their comparison And the regulation of STATCOM
- To analyze the functioning and control of GCSC, TSSC and TCSC

**Course Outcomes:** Upon the completion of the subject, 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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## POWER SYSTEM OPERATION AND DEREGULATION

**Prerequisite: Power System Operation and Control**
**Course objectives:**

- To find OPF with security constraints.
- To generalize modeling of load frequency control of a power system
- To compute reactive power control of a power system.
- To apply the concept of deregulation and ATC.

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

- Know the optimal scheduling of power plants
- Outline the modeling of turbine and generator
- Compute the steady state behavior of the power system for voltage and frequency fluctuations.
- Analyze ATC and the cost of transmission

**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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**GAS INSULATED SYSTEMS (GIS)**
**(Core Elective–III)**

**Prerequisite: Switch Gear and Protection**
**Course objectives:**
- To know the GIS concepts and principles
- To choose Air Insulated Substation and GIS
- 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 the subject, 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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## PROGRAMMABLE LOGIC CONTROLLERS AND THEIR APPLICATIONS
**(Core Elective-III)**

**Prerequisite: No Prerequisite**
**Course Objectives**

- It is to provide and ensure a comprehensive understanding of using advanced controllers in measurement and control instrumentation.
- To illustrate about data acquisition - process of collecting information from field instruments.
- To analyze Programmable Logic Controller (PLC), IO Modules and internal features.
- To Comprehend Programming in Ladder Logic, addressing of IO.
- To apply PID and its Tunning.

**Course Outcomes**

- Describe the main functional units in a PLC and be able to explain how they interact.
- They should know different bus types used in automation industries.
- Development of ladder logic programming for simple process.
- At the end of each chapter, review question, problems given to reinforce their understanding of the concepts.

**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.


**REFERENCE BOOKS:**

**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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## HIGH FREQUENCY MAGNETIC COMPONENTS
**(Core Elective –III)**

**Course Objectives:**

- To have a knowledge on magnetic circuits
- To know the skin effect and proximity effect

**Course Outcome:**

- Design of magnetic components (i.e., inductor and transformer) in a converter,
- Steady-state analysis of switched mode power supply
- define core loss in an electromagnetic device, and recognise & 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 BOOK:**


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”
11. Ferroxcube --- “3f3 ferrite datasheet.pdf”
12. Ferroxcube --- “Ferrite selection guide.pdf”
13. Magnetics, Inc., Ferrite Cores (www.mag-inc.com).

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## REACTIVE POWER COMPENSATION AND MANAGEMENT
## (Core Elective –IV)

**Prerequisite: Power Systems-II**
**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 contrast reactive power coordination system
- To characterize distribution side and utility side reactive power management.

**Course Outcomes:** Upon the completion of the subject, 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 are 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, Wiely publication.

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## POWER SYSTEM RELIABILITY
**(Core Elective–IV)**

**Prerequisite: Reliability Engineering**
**Course Objectives:**
- To identify the generation system model and recursive relation for capacitive model building
- To calculate the equivalent transitional rates, cumulative probability and cumulative frequency
- To classify the risk, system and load point reliability indices
- To evaluate the basic reliability indices

**Course Outcomes:** Upon the completion of the subject, the student will be able to
- Find loss of load and energy indices for generation systems model
- Describe merging generation and load models
- Apply various indices for distribution 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 – Modelling 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.
**Distribution System Reliability Analysis – I (Radial configuration):** 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.

**UNIT-V:**
**Distribution System Reliability Analysis - II (Parallel Configuration):** Basic techniques – inclusion of bus bar failures, scheduled maintenance – temporary and transient failures – weather effects – common mode failures –Evaluation of various indices – Examples
**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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## VOLTAGE STABILITY
**(Core Elective–IV)**

**Prerequisite: Computers Methods in Power Systems**

**Course Objectives:**

- To choose SEC Planning and Operational Standards of Security
- To estimate Reactive Power Control in Generation/Transmission Interconnected Networks
- To apply sstability/Instability in Generation/Transmission Interconnected Networks
- To analyze design and Operational Solutions
- To characterize voltage Control in Distribution Networks

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

- Understand issues related to power system stability and control.
- Demonstrate various load models in voltage stability analysis.
- Detect 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 SMLB 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; 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, Mc Graw Hill, 1994.

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**INSTRUMENTATION AND CONTROL**
**(Open Elective – II)**

**Course Objectives:**

- To provide good knowledge of Instrumentation systems and their applications.
- To provide knowledge of advanced control theory and its applications to engineering problems.
- To have a comprehensive idea about P,PI,PD,PID controllers

**Course Outcomes:**

- Ability to understand and analyze Instrumentation systems and their applications to various industries.
- Ability to apply advanced control theory to practical engineering problems.

**Unit-I**
Instrumentation: Introduction to mechanical systems and their structure and function, Performance Characteristics – Static and Dynamic, Fundamentals of signals acquisition, conditioning and processing,

**Unit-II**
Measurement of temperature, pressure, flow, position, velocity, acceleration, force, torque etc.

**Unit-III**
Control: Introduction to control systems, mathematical model of physical systems in transfer function and state space forms, response of dynamic systems, concept of pole & zero of a system,

**Unit-IV**
Realization of transfer functions, stability analysis. Introduction of discrete time system. Controllers: P, PI, PD, PID, Feed forward etc., tuning of controller parameters, disturbance rejection, implementation of controller using digital computer.

**Unit-V**
Control components: Actuator (ac & dc servomotors, valve), AC, DC tacho-generators, servo amplifier.

**TEXT BOOKS:**

1. Jhon P Bently, "Principles of Measurement Systems" 3rd. Edition, Pearson
2. Alok Barua, "Fundamentals of Industrial Instrumentation' Wiely India, 2011
3. William Bolton, "Instrumentation and Control Systems"Elsevier, 2015

**REFERENCES:**

1.William Bolton, "Industrial Control and Instrumentation" University Press, 1991
2.Norman A Anderson," Instrumentation for Process Measurement and Control" CRC, 1997
3.A. K, Ghosh, " Introduction to Instrumentation and Control" Prentice Hall of India, 2005

**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD**

**M. TECH – I YEAR – II SEM. (EPE/EPS/PEES/PSC&A)**

## INTELLIGENT CONTROL
## (Open Elective-II)

**Course Objectives:**

- Gaining an understanding of the functional operation of a variety of intelligent control techniques and their bio-foundations
- the study of control-theoretic foundations
- learning analytical approaches to study properties

**Course Outcome:**

- To give a solid understanding of Basic Neural Network, Fuzzy Logic and Genetic algorithms.
- To know how to use Soft Computing to solve real-world problems mainly pertaining to Control system applications

**Unit-I**

Introduction and motivation. Approaches to intelligent control. Architecture for intelligent control. Symbolic reasoning system, rule-based systems, the AI approach. Knowledge representation. Expert systems.

**Unit-II**

Concept of Artificial Neural Networks and its basic mathematical model, McCulloch-Pitts neuron model, simple perceptron, Adaline and Madaline, Feedforward Multilayer Perceptron. Learning and Training the neural network. Data Processing: Scaling, Fourier transformation, principal-component analysis.

**Unit-III**

Networks: Hopfield network, Self-organizing network and Recurrent network. Neural Network based controller Case studies: Identification and control of linear and nonlinear dynamic systems using Matlab-Neural Network toolbox. Stability analysis of Neural-Network interconnection systems.

**Unit-IV**

Genetic Algorithm: Basic concept of Genetic algorithm and detail algorithmic steps, adjustment of free parameters. Solution of typical control problems using genetic algorithm. Concept on some other search techniques like tabu search and ant-colony search techniques for solving optimization problems.

**Unit-V**

Introduction to crisp sets and fuzzy sets, basic fuzzy set operation and approximate reasoning. Introduction to fuzzy logic modeling and control. Fuzzification, inferencing and defuzzification. Fuzzy knowledge and rule bases. Fuzzy modeling and control schemes for nonlinear systems. Fuzzy logic control for nonlinear time-delay system. Implementation of fuzzy logic controller using Matlab fuzzy-logic toolbox. Stability analysis of fuzzy control systems.

**TEXT BOOKS**


1. Simon Haykins, Neural Networks: A comprehensive Foundation, Pearson Edition, 2003.
2. T.J.Ross, Fuzzy logic with Fuzzy Applications, Mc Graw Hill Inc, 1997.
3. David E Goldberg, Genetic Algorithms.
4. John Yen and Reza Langari, Fuzzy logic Intelligence, Control, and Information, Pearson Education, Indian Edition, 2003.


**REFERENCES**


1. M.T.Hagan, H. B. Demuth and M. Beale, Neural Network Design, Indian reprint, 2008.
2. Fredric M.Ham and Ivica Kostanic, Principles of Neurocomputing for science and Engineering, McGraw Hill, 2001.
3. N.K. Bose and P.Liang, Neural Network Fundamentals with Graphs, Algorithms and Applications, Mc - Graw Hill, Inc. 1996.
4. Yung C. Shin and Chengying Xu, Intelligent System - Modeling, Optimization and Control, CRC Press, 2009.
5. N.K.Sinha and Madan M Gupta, Soft computing & Intelligent Systems - Theory & Applications, Indian Edition, Elsevier, 2007.
6. Witold Pedrycz, Fuzzy Control and Fuzzy Systms, Overseas Press, Indian Edition, 2008.

**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD**
**M. TECH – I YEAR – II SEM. (EPE/EPS/PEES/PSC&A)**

**SMART GRID TECHNOLOGIES**
**(Open Elective–II)**

**Prerequisite: Electrical and Electronic Instrumentation**
**Course Objectives:**

- To group various aspects of the smart grid,
- To defend 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 the subject, the student will be able to

- Recite the structure of an electricity market in either regulated or deregulated market conditions.
- Understand the advantages of DC distribution and developing technologies in distribution
- Discriminate the trade-off 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 development 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 intelligrid-Intelligrid today- Smart grid vision based on the intelligrid 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 Efficiencyand Demand Side Response”- CRC Press, 2009.
2. Jean Claude Sabonnadière, NouredineHadjsaïd, “Smart Grids”, Wiley-ISTE, IEEE Press,May 2012

**REFERENCES:**

1. JanakaEkanayake, KithsiriLiyanage,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.

**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD**
**M. TECH – I YEAR – II SEM. (EPE/EPS/PEES/PSC&A)**

## AI TECHNIQUES IN ELECTRICAL ENGINEERING
**(Open Elective-II)**

**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 the subject, the student will be able to

- Quote feed forward neural networks and learning and understanding of feedback neural networks.
- Generalize fuzziness involved in various systems and fuzzy set theory.
- Select fuzzy logic control and design
- Examine genetic algorithm and 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 cartesion 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 BOOK:**

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


**REFERENCE BOOKS:**

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.

**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD**
**M. TECH – I YEAR – II SEM. (EPE/EPS/PEES/PSC&A)**

## RELIABILITY ENGINEERING
### (Open Elective –II)

**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.

**Learning Outcomes**
- Apply fundamental knowledge of Reliability to modeling and analysis of series-parallel and Non-series parallel systems.
- Solve some practical problems related with Generation, Transmission and Utilization of Electrical Energy.
- 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 cutsets from Event tree.

**Unit IV:**
Discrete Markov Chains: General modelling concepts, stochastic transitional probability matrix, time dependent probability evaluation and limiting state probability evaluation of one component repairable model. Absorbing states.
Continuous Markov Processes: Modelling 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.

**REFERENCE BOOKS:**
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.

**M. TECH – I YEAR – II SEM. (EPE/EPS/PEES/PSC&A)**

## ENERGY AUDITING, CONSERVATION AND MANAGEMENT
**(Open Elective –II)**

**Prerequisite: Electrical Distribution Systems**

**Course Objectives:**

- To know the necessity of conservation of energy
- To generalize the methods of energy management
- To illustrate the factors to increase the efficiency of electrical equipment
- To detect the benefits of carrying out energy audits.

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

- Tell energy audit of industries
- Predict management of energy systems
- Sequence the methods of improving efficiency of electric motor
- Analyze the power factor and to design a good illumination system
- Determine pay back periods for energy saving equipment

**UNIT-I:**

**Basic Principles of Energy Audit:** Energy audit- definitions, concept , types of audit, energy index, cost index ,pie charts, Sankey diagrams, load profiles, Energy conservation schemes- Energy audit of industries- energy saving potential, energy audit of process industry, thermal power station, building energy audit.

**UNIT-II:**

**Energy Management:** Principles of energy management, organizing energy management program, initiating, planning, controlling, promoting, monitoring, reporting- Energy manger, Qualities and functions, language, Questionnaire – check list for top management.

**UNIT-III:**

**Energy Efficient Motors:** Energy efficient motors , factors affecting efficiency, loss distribution , constructional details , characteristics - variable speed , variable duty cycle systems, RMS hp- voltage variation-voltage unbalance- over motoring- motor energy audit

**UNIT-IV:**

**Power Factor Improvement, Lighting and Energy Instruments:** Power factor – methods of improvement, location of capacitors, Pf with non linear loads, effect of harmonics on power factor, power factor motor controllers - Good lighting system design and practice, lighting control ,lighting energy audit - Energy Instruments- wattmeter, data loggers, thermocouples, pyrometers,lux meters, tongue testers ,application of PLC's.

**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- calculation of simple payback method, net present worth method- Power factor correction, lighting - Applications of life cycle costing analysis, return on investment .

**TEXT BOOKS:**

1. Energy management by W.R. Murphy AND G. Mckay Butter worth, Heinemann publications.
2. Energy management by Paul o' Callaghan, Mc-graw Hill Book company-1st edition, 1998

**REFERENCES:**

1. Energy efficient electric motors by John .C. Andreas, Marcel Dekker Inc Ltd-2nd edition, 1995-
2. Energy management hand book by W.C.Turner, John wiley and sons
3. Energy management and good lighting practice : fuel efficiency- booklet12-EEO

**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD**

**M. TECH – I YEAR – II SEM. (EPE/EPS/PEES/PSC&A)**

**POWER SYSTEM LAB – II**

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