Indus University
Indus Institute of Technology & Engineering
Department of Electrical Engineering

M.Tech in Electrical Engineering (Electrical Power System)

PS5101206 Advanced Power System Protection

Course Contents

[Unit 1] Principle of Power System Protection [10]

Review of principles of power system protection, Classification of relay, Trip circuit, Main and Back-up protection, Over current protection, Distance protection, Directional protection, Differential protection, System protection, Desirable Attributes of Protection.

[Unit 2] Numerical (digital) Protection [15]

Introduction, Advantages of Numerical relays, Comparison of electromagnetic, static and digital relay, Block diagram and components of digital relay, Sampling theorem, Least Square Method for Estimation of Phasors, Co-Relation with reference wave, Fourier analysis of analogous Signals, Discrete Fourier transform, Walsh–Hadamard analysis, Digital Filtering, Simple low-pass filter, Simple high-pass filter, FIR filter, IIR filters, Comparison between FIR & IIR filters, Numerical over current protection, Numerical transformer differential protection, Numerical distance protection.

[Unit 3] Carrier Aided protection for Transmission Line [10]

Requirement for carrier-aided protection, Coupling and trapping the carrier signals into the desired line section, Unit type carrier-aided directional comparison relaying, Carrier-aided distance schemes acceleration Zone II, Phase comparison relaying carrier protection.

[Unit 4] Power apparatus Protection [15]

Generator Protection-Various faults and abnormal operating conditions, Stator-Rotor Earth Fault Protection, Protection against unbalanced loading and loss of Excitation, Over-speeding, loss of prime mover, Numerical approach for generator protection.
Transformer Protection-Percentage differential protection, Inrush phenomenon, Inter-turn faults in transformers, Incipient faults in transformer, Restricted earth fault protection, Protection against over fluxing, Numerical Approach for

Transformer protection, **Buszone Protection**- Requirements, Unit and non-Unit protection, Breaker Back up protection.

References:

1. Paithankar, Y.G., Bhide, S.R., "Fundamentals of Power System Protection," PHI Learning Pvt. Ltd., New Delhi.
2. Oza, Bhuvanesh, Nair, N.C., Mehta, R.P., Makwana V.H., "Power System Protection and Switchgear," Tata McGraw-Hill, New Delhi, 2010.
3. Rao, S.S., "Switchgear and Protection: theory, practice and solved problems," Khanna Publisher, New Delhi.
4. Ravindranath, B., Chander, M., Power System Protection and Switchgear," New Age international (P) Ltd, New Delhi.
5. Singh Ravindra P. "Switchgear and Power System Protection" PHI Learning Pvt.Ltd., New Delhi.

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PS510207 Optimization Techniques

Course Contents

[Unit 1] **[09]**

Linear programming, formulation-Graphical and simplex methods-Big-M method-Two phase method-Dual simplex method-Primal Dual problems.

[Unit 2] **[09]**

Unconstrained one dimensional optimization techniques -Necessary and sufficient conditions –Unrestricted search methods-Fibonacci and golden section method-Quadratic Interpolation methods, cubic interpolation and direct root methods.

[Unit 3] **[09]**

Unconstrained n dimensional optimization techniques – direct search methods – Random search –pattern search and Rosen brooch's hill climbing method- Descent methods-Steepest descent, conjugate gradient, quasi -Newton method.

[Unit 4] **[09]**

Constrained optimization Techniques- Necessary and sufficient conditions – Equality and inequality constraints-Kuhn-Tucker conditions-Gradient projection method-cutting plane method- penalty function method .

[Unit 5] **[09]**

Dynamic programming- principle of optimality- recursive equation approach-application to shortest route, cargo-loading, allocation and production schedule problems.

Reference books:

1. Rao,S.S., Optimization :Theory and Application" Wiley Eastern Press, 2nd edition 1984.

2. Taha,H.A., Operations Research –An Introduction, Prentice Hall of India,2003.

3. Fox, R.L., „Optimization methods for Engineering Design", Addition Welsey, 1971.

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PS510208 Advanced Power System Stability

Course Contents

[Unit 1] Introduction to Power System Stability Problem [06]

Introduction, Basic Concept of Power system stability problem, Rotor angle stability, Concept of Voltage collapse, mid-term and long term stability, classification of stability, Review of Stability Problem

[Unit 2] Small Signal Stability for Single Machine & Multi Machine System [12]

Small signal stability of single machine infinite bus system by means of Classical model, block diagram representation, effect of excitation system, effect of AVR and Damping torque component, Power System stabilizer, Small signal stability for multi machine system, Formulation of state Equation, representation of static load, Analysis of large system and AESOPS algorithms

[Unit 3] Torsional Characteristics & Sub Synchronous Oscillation [09]

Introduction, Turbine-generator torsional Characteristics, Shaft system Model Torsional interaction with Power System Control, Sub synchronous resonance, Characteristics of series capacitor, Self excitation due to induction generator effect, analytical method and torsional interaction resulting SSR, Countermeasures to SSR Problems

[Unit 4] Voltage Collapse & Stability [09]

Basic concept of Voltage stability, Comparison of Angle and Voltage stability, Typical scenario of voltage collapse, Classification if voltage stability, Voltage stability analysis, Modeling requirements, Dynamic Analysis

[Unit 5] Transient Stability [09]

Basic concept of transient stability, Simulation of dynamic system, structure of power system, excitation system representation, Analysis of unbalanced faults, Symmetrical components, sequence impedances, Simulation of different types of faults, Case study of transient stability of large machine system

Text\ Reference Books:

1.	P. S. Kundur		Power System Stability and Control, McGraw Hill Inc, New York.
2.	K.R.Padiyar	-	Power System Dynamics - Stability and Control, BS Publishers, Hyderabad
3..	J. Machowski, J.W. Bialek, J.R. Bumby	-	Power System Dynamics, Stability and Control, Wiley publishers
4..	P.Sauer and M.A.Pai	-	Power System Dynamics and Stability, Prentice Hall.
5.	Ajarappa	-	The Techniques for Computation of Voltage Stability Assessment, Wiley IEEE Press
6.	I. J. Nagrath and D. P. Kothari	-	Modern Power Systems Analysis, Tata McGraw Hill.

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PS510209 HVDC & FACTS

Course Contents

[Unit 1] Introduction [12]

Background, Electrical Transmission Networks, Conventional Control, Mechanisms, Flexible ac Transmission Systems (FACTS), Emerging Transmission Networks.

HVDC transmission and Converter Circuit

Comparison of AC and DC transmission, Advantages and Disadvantages of DC transmission, Kinds of DC links and its applications, MTDC System, Components of HVDC transmission, HVDC systems in world and India Valve Characteristics, Single phase converters, Three phase converters, Graetz Circuit, Additional six pulse converter circuits and twelve pulse converter

[Unit 2] Principles of Reactive-Power Compensators: [15]

Synchronous Condensers, The Saturated Reactor (SR), The Thyristor-Controlled Reactor (TCR), The Thyristor-Controlled Transformer (TCT), The Fixed Capacitor-Thyristor-Controlled Reactor (FC-TCR), The Mechanically Switched Capacitor-Thyristor-Controlled Reactor (MSC-TCR), The Thyristor-Switched capacitor and Reactor, The Thyristor-Switched capacitor-Thyristor-Controlled Reactor (TSC-TCR), A Comparison of Different SVCs, Summary.

Series Compensation, The TCSC Controller, Operation of the TCSC, The TSSC, Analysis of the TCSC, Open-Loop Control, Closed-Loop Control, Improvement of the System-Stability Limit, Enhancement of System Damping, Sub synchronous Resonance (SSR) Mitigation, Voltage-Collapse Prevention, TCSC Installations.

[Unit 3] Concepts of SVC Voltage Control & its Application [15]

Voltage Control, Effect of Network Resonances on the Controller Response, The 2nd Harmonic Interaction between the SVC and ac Network, Application of the SVC to Series-Compensated ac Systems, 3rd Harmonic Distortion, Voltage-Controlled Design Studies, Increase in Steady-State Power-Transfer Capacity, Enhancement of Transient Stability, Augmentation of Power-System Damping, SVC Mitigation of Sub synchronous Resonance (SSR), Prevention of Voltage Instability

[Unit 4] Emerging FACTS Controllers [06]

The STATCOM, The SSSC, The UPFC, Comparative Evaluation of Different FACTS Controllers, Future Direction of FACTS Technology.

[Unit 5] Grid Control, Harmonics and Filters [12]

Grid control and its characteristics, limitations of manual control, constant current versus constant voltage system, Actual control characteristics, individual and combined control
Measurement of DC current, voltage, power Reactive power requirements, Sources of reactive power, SVS

Generation of AC and DC harmonics, Characteristic Harmonics and uncharacteristic harmonics, Fourier analysis of valve currents and line currents on valve side Means of reducing harmonics, AC filters and DC filters

Reference Books:

1. Thyristor-based FACTS controllers for Electrical Transmission Systems: R Mohan Mathur, R K Verma, Wiley IEEE Press.

2. Understanding FACTS, N.G.Hingorani and L.Gyugyi, Standard Publishers, Delhi, 2001.

3. FACTS Controllers in Power Transmission & Distribution: Padiyar K R, New Age International (P) Limited.

4. Reactive Power Control in Electric Systems: T J E Miller, John Willey.

5. Power System Stability and Control, Prabha Kundur, Tata McGrahill.

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PS510210 Substation Design & Automation

Course Contents

[Unit 1] Introduction to substations and design process [06]

Introduction, Background, Classification of substations Need determination, Budgeting, Financing, Traditional and Innovative substation design, Selection and location of site for a substation, Design, construction and commissioning process

[Unit 2] Air -Insulated Substations and Gas - Insulated Substation [09]

Bus/switching configurations, various types of Bus arrangements, Components and equipments, High voltage switching equipment: Disconnect and load break switches, High speed grounding switches, Circuit-breakers. Selection and ratings of various equipments for a particular substations, Introduction to GIS, Sulfur Hexafluoride Insulating gas, Construction and service life, Advantages and economics of GIS

[Unit 3] Substation Grounding and SLD of substation [09]

Reasons for substation grounding system, Accidental ground circuits, Permissible Body current limits, Tolerable voltages, Design criteria, Soil resistivity, grid resistance, grid current, Selection of electrodes and conductors for grounding system, Fire protection objectives and philosophies, Fire Hazards, Typical Fire protection measures Key diagrams of typical substations, Distribution substation, High Voltage substation, EHV substation.

[Unit 4] Substation Interface, Automation and Integration [12]

Introduction, Physical Considerations, Analog Data Acquisition, Status Control Functions, Communications Networks inside the Substation, Testing Automation Systems. Introduction, Definitions and Terminology, Open Systems, Architecture Functional Data Paths, Substation Integration and Automation System Functional

Architecture, New vs. Existing Substations, Equipment Condition, Substation Integration and Automation Technical Issues, Protocol Fundamentals, Protocol Considerations, Choosing the Right Protocol, Communication Protocol Application Areas

[Unit 5] Substation Communications [09]

Introduction, Supervisory Control and Data Acquisition (SCADA) Historical Perspective, SCADA Functional Requirements, SCADA Communication Requirements, Components of a SCADA System, SCADA Communication Protocols: Past, Present, and Future, The Structure of a SCADA Communications Protocol, Security for Substation Communications, Electromagnetic Environment, Communications Media

Text/Reference Books:

1. J. D. McDonald (Ed). Electric Power Substations Engineering, CRC Press
2. P. S. Satnam and P. V. Gupta Substation Design and Equipment, Dhanpat Rai and Sons
3. M. S. Naidu Gas Insulated Substations, I. K. International Publishing House Pvt. Ltd., New Delhi

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PS510213 Distributed Generation & Microgrid

Course Contents

[Unit 1] Introduction [12]

Conventional power generation: advantages and disadvantages, Energy crises, Non-conventional energy (NCE) resources: review of Solar PV, Wind Energy systems, Fuel Cells, micro-turbines, biomass, and tidal sources.

[Unit 2] Distributed Generation (DG) [12]

Concept of distributed generations, topologies, selection of sources, regulatory standards/framework, Standards for interconnecting Distributed resources to electric power systems: IEEE 1547. DG installation classes, security issues in DG implementations. Energy storage elements: Batteries, ultra-capacitors, flywheels. Captive power plants

[Unit 3] Impact of grid Integration [12]

Requirements for grid interconnection, limits on operational parameters,: voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues. Impact of grid integration with NCE sources on existing power system: reliability, stability and power quality issues

[Unit 4] Basics of Microgrid [12]

Concept and definition of microgrid, microgrid drivers and benefits, review of sources of microgrids, typical structure and configuration of a microgrid, AC and DC microgrids, Power Electronics interfaces in DC and AC microgrids,

[Unit 5] Control & Operation of Micro grid [12]

Modes of operation and control of micro grid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques, micro grid communication infrastructure, Power quality issues in micro grids, regulatory standards, Micro grid economics, Introduction to smart micro grids.

Reference:

1. Distributed generation Micro grid operation By Hatem Hussein Magdy Zeineldin, University of Waterloo (Canada)
2. Micro grids and Active Distribution Networks By S. Chowdhury, S.P. Chowdhury and P. Crossley - The Institution of Engineering and Technology, London.
3. Control and optimization of Distributed generation system By Magdi S Mahmoud – Springer
4. Distributed generation and its implications for the utility industry By Fereidoon P Sioshansi – Academic Press